Colonial Museum and Geological Survey Department.

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REPORTS

OF

GEOLOGICAL EXPLORATIONS

DURING 1879-80,

WITH MAPS AND SECTIONS.

PUBLISHED BY COMMAND.

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CONTENTS.

ILLUSTRATIONS.

REPORTS OF THE GEOLOGICAL SURVEY.

PROGRESS REPORT, 1879-80.

A NUMBER of important surveys have been made during the past season, but, owing to my protracted absence from the colony in connection with the Sydney Exhibition, the field work for the year has chiefly devolved on Messrs. Cox and McKay, certain special reports having been obtained from Mr. W. E. Rowe, who was temporarily employed for the purpose.

Reports have been obtained on the following mines:—

Antimony Lodes.

Hindon.
Stony Creek.

Copper Lodes.

Big Bay.
Dusky Sound.
Waitahuna.
Aniseed Valley.
" (Johnston's).
Roding River.
Dun Mountain.

Chrome Lodes.

Ben Nevis.
Dun Mountain.
Aniseed Valley.

Auriferous Reefs.

Wairarapa.
Longwood Range.
Mount Ophir, Collingwood.
Mount Arthur.

Coal Seams.

Paringa River.
Springfield.
Motunau.
Picton.

The following extensions of the Geological Survey have afforded important additions to the general mapping of the colony:—

1. *Auckland District.*—The country lying between Whangarei and Kaipara, about 1,500 square miles.
2. *Canterbury District.*—The country between Motunau and the Rakaia River, about 1,000 square miles.
3. *Otago District.*—Special examination of the Jurassic strata at the Mataura.

4. *Otago District.*—The alpine district lying to the north-west of the Wakatipu Lake, about 1,400 square miles.

The comparison of the geology of New Zealand with that of Australia formed the subject of a lecture delivered by myself in Sydney, which has been printed in the Transactions of the Royal Society of New South Wales,* and from which the following extract may have interest for New Zealand geologists:—

"On the whole the geological record, so far as yet known, is more complete in the New Zealand than in the Australian area. The Tertiary strata are perhaps equally well developed, and the distinguishing facies of each existing fauna is discernible as early as the Eocene formations. The Upper Mesozoic formations are very imperfectly represented in Australia, but have enormous development in New Zealand, in which country, as in America, the Tertiary facies of the fauna and flora springs from a shore-line and land surface of præ-cretaceous age. This is the period of the chief coal deposits in New Zealand.

"It was in the Lower Mesozoic period that the greatest divergence in the character of the deposits prevailed in the several areas. In Australia, marine Jurassic formations, which can be determined by their fossils, are not extensively developed, while the characteristic fauna of the Trias has not yet been detected (with the exception of *Estheria*, recently detected in the core excavated by the diamond drill from under the Sydney sandstone); fossil plants, which are most uncertain guides, being alone found in the strata which must be referred to that period. In New Zealand, on the other hand, three divisions of the Jurassic formation have been distinguished by their abundant fossil contents. A Liassic formation has a fair development, while an Upper Trias or Rhœtic formation has an importance due to thickness and variety of fossils which is unknown elsewhere. The Trias, with its very characteristic molluscous fauna, is also largely developed, and also occurs in New Caledonia. Without any marked break the sequence in New Zealand passes down into a thick formation with Permian fossils, but associated with forms found in the Trias, while the more strictly palæozoic elements of the Permian fauna are absent. This is followed in New Zealand by a gap, and the next formation, which is Lower Carboniferous and Upper Devonian, is the latest formation, according to our

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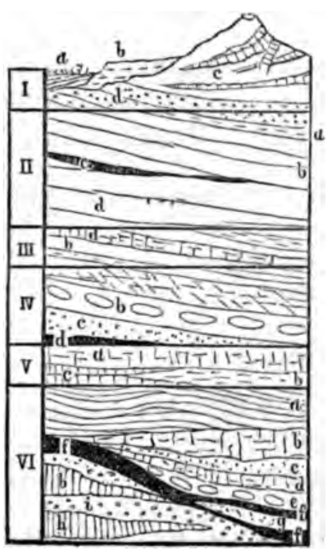
* Jour. Roy. Soc. N.S.W., Vol. XIII., 1880, p. 65.

present evidence, which appears to have been common to Australia and New Zealand, and to have been deposited in both areas under the same physical conditions and within a common biological province.

"The attempt to correlate the Lower Mesozoic formations in the two countries is therefore a matter of some difficulty; but as plant-beds occur at intervals, interstratified with the marine strata of New Zealand, these may be perhaps yet employed successfully as indications of relative age.

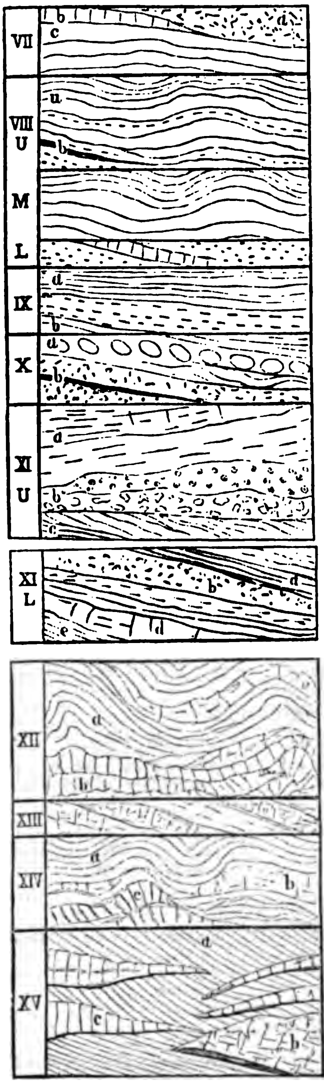
"This would be a most useful labour, as the strata concerning the age of which there is so much uncertainty are in Australia and India of the highest economic importance from their containing workable coal-seams; but while the Upper Jurassic flora is well developed in New Zealand, and can be successfully compared with that of corresponding age in Australia and India, the lower plant-beds of Rhœtic, Triassic, and Permian age have only yielded specimens in a bad state of preservation. The following attempt at a tabular comparison of the age of the formations in the two countries is therefore not made altogether on palæontological evidence, and is only the reading of the Australian record from the New Zealand point of view, so far as the characters and subdivisions of the Australian formations have been described by various authors :—

"TABLE OF FOSSILIFEROUS FORMATIONS.



New Zealand.	Australia.
I. Recent—	Newer gold drift, scoriaceous lavas of Victoria.
a. Moa beds	
b. Alluvia	
c. Volcanic	
d. Shingle plains	
II. Pliocene—	Older gold drifts and deep leads of Victoria.
a. Shingle plains	
b. Pumice sands	
c. Lignite beds	
d. Kereru beds	
III. Upper Miocene—	Limestones of South Australian Bight.
a. Wanganui beds	
b. Awatere beds	
IV. Lower Miocene—	Portland beds of Victoria.
a. Ross beds	Murray River beds.
b. Mangapakeha beds	
c. Pareora beds	
V. Upper Eocene—	Schnapper Point beds of Victoria.
a. Mt. Brown beds	
b. Oamaru beds	Table Cape, Tasmania.
c. Nummulitic beds	
VI. Cretaceo-Tertiary—	New Britain?
a. Grey marls	
b. Ototara stone	New Caledonia?
c. Fucoidal greensand	
d. Amuri limestone	Queensland?
e. Island sandstone	
f. COAL FORMATION OF NEW ZEALAND	
g. Black grit	
i. Conglomerate	
h. Propylite breccias	

"TABLE OF FOSSILIFEROUS FORMATIONS—*continued.*



New Zealand.	Australia.
VII. Neocomian— *a.* Conglomerates with coal *b.* Porphyries *c.* Greensands	Flinders River beds, Queensland. New Caledonia.
VIII. Jurassic— U. Upper— *a.* Mataura beds *b.* Coal seams M. Middle— Putataka beds L. Lower— Flag Hill beds	Queensland, West Australia. Clarence River coal, N.S.W. Jerusalem coal, Tasmania. Rajmahal plant-beds, India. Cape Paterson, Victoria.
IX. Liassic— *a.* Catlin's River beds *b.* Bastion beds	Queensland?
X. Rhœtic and Triassic— *a.* Otapiri beds *b.* Wairoa beds	Wianamatta Shales, N.S.W. New Caledonia.
XI. Permian— U. Upper— *a.* Oreti beds *b.* Great conglomerate *c.* Great sandstones	Hawkesbury sandstones. Conglomerate, Lake Macquarie? Gondwana series, India.
L. Lower— *a.* Mount Potts beds *b.* Kaihiku beds *c.* Glossopteris beds *d.* Conglomerates *e.* Red sandstones Wanting?	Newcastle Coal Measures, N.S.W. Stony Creek beds and Wollongong beds, N.S.W.
XII. Lower Carboniferous *a.* Maitai slates *b.* Te Anau beds	Port Stephens beds, N.S.W. Tasmania. Gympie Creek, Queensland.
XIII. Lower Devonian—Reefton beds	Murrumbidgee beds, N.S.W.
XIV. Upper Silurian— *a.* Baton River slates *b.* Limestones *c.* Serpentinous slates	Yass and Hume beds, N.S.W. Gordon River, Tasmania.
XV. Lower Silurian— *a.* Graptolite *b.* Marbles *c.* Hornblende rocks."	Auriferous slates of Victoria.

HINDON ANTIMONY MINE.

Mr. Rowe was employed to report on the Hindon Antimony Mine, some miles from Dunedin, in which locality auriferous quartz reefs, carrying patches of stibnite or sulphide of antimony, have been known since 1864. His report states that the lode is 18 feet thick, but only carries antimony near its foot-wall. He confirms the previous reports to the effect that it is essentially a poor auriferous quartz reef so far as yet exposed, and has no claim to the title of an antimony mine; and recommends that a drive be put in along the strike of the reef, making the foot-wall one side of the level, cross-cutting the lode at intervals of 20 feet, rises being put up and winzes sunk where the indications are favourable.

STONY CREEK ANTIMONY MINE.

He also examined the Stony Creek Antimony Mine, at Upper Waipori, and reports that the lode is 2½ feet thick, structure massive, formation regular; walls friable, consisting of decomposed schist, interspersed with small veins of quartz intersecting each other in all directions. The lode is composed of fibrous and compact stibnite, the former being almost pure sulphide of antimony, and the latter containing on an average 30 per cent. of gangue. It has been traced for a distance of 200 feet. An adit-level opened 7 feet above the bed of the creek has been driven east on the course of the lode for 30 feet, showing a very promising lode in the face. The returns from four tons of ore broken in this drive, and sold, show 47 per cent. of metallic antimony. A shallow shaft has been sunk on the lode on the top of the spur, from which 30 cwt. of ore was taken, and sold with slightly better results.

COPPER MINES.

Mr. Macfarlane, Government Agent at Jackson's Bay, has forwarded a sample of copper ore (chalcopyrite) which was taken from a lode 3 feet wide, cropping out at an altitude of about 2,000 feet above sea-level, near Big Bay. A band in this lode, 18 inches wide, consists of a mixed ore, chalcopyrite and iron pyrites, containing 18·55 per cent. of copper; while the rest of the lode is composed of quartz which is permeated by thin bands of the same ore, the proportion of which to the whole mass would be about 4 per cent. The hanging-wall of the lode is mica-schist, and the foot-wall green slate. The lode is well defined, and has been traced for a considerable distance.

At the commencement of the present year, Mr. W. E. Rowe was employed to report on the operations which had been carried on at Dusky Sound, as it was inconvenient at that time to send any of the permanent officers of the department to inspect the works. He reports that the prospects of the mine at the present time are but small, no reef having been cut in either of the cross-cut levels, and that where Mr. Cox recommended the first work to be done—viz., at the outcrop of the lode—not more than a fortnight's work for two men has been expended; this work showing that the lode splits into a number of small veins of copper pyrites, which he thinks are offshoots of a lode that formerly rested upon the north-west side of the spur as its foot-wall. He also states that no work whatever has been expended at the foot of the cliff, where copper ore might be expected to be found, and points out that to leave the outcrop and drive cross-cuts when the lode was splitting up as described was extremely ill-advised. Mr. Rowe has since examined the ground owned by the company more in detail, and his report was forwarded to me for publication. In this second report he appears to take a very hopeful view of the deposits, after studying them more carefully.

Mr. Rowe also visited an outcrop of copper ore in Reedy Creek, at the head of the Waitahuna River; but owing to the small shafts having been filled with water, and the river, which had been wing-dammed some time ago, having now resumed its former course, he was unable to see anything of the lode. He however reports that the blocks of copper ore which have been raised and are laid on the ground guarantee the existence of a lode at least 2 feet thick, and he was informed that at a depth of 9 feet, in a small shaft, the lode was 4 feet thick, and consisted of the yellow sulphide.

Mr. Cox visited the Aniseed Valley Company's Copper Mine, in Nelson, but it was not being worked at the time. The ore, however, had only been found in pockets, and when these have been worked out the country gives no indications of copper; but, as these patches have, up to the present time, been pretty frequent in their occurrence, there is some inducement to continue the works.

He also examined the so-called copper stratum discovered by Messrs. Johnston Brothers in Aniseed Valley, and reports that the ore in question consists of a granular serpentine, through which metallic copper is disseminated in minute grains; and this ore tested in the Laboratory has been found to yield from 2 to 6 per cent. of copper. The metal is very regularly distributed through the stone where it has been found, and would probably average about 5 per cent. of metallic copper. It occurs on the north-west side of the mineral belt in the same line of country as all the other copper and chrome deposits which have yet been found, and, like them, it appears to follow the line of the mineral belt. No definite opinion of its value can be formed at present, considering how little has been done to open up the mine, and as—although the rock in question has been found *in situ* on the banks of the Serpentine River, and at Johnston's outcrop below the old chrome workings in Aniseed Valley, and also boulders in several localities as far as the Dun Mountain—the outcrops have not as yet been traced continuously for more than a few feet, so that they may be nothing more than local patches.

He examined the workings in the Roding River Copper Mine, but reports that, very little work having been expended here, no reliable opinion can be formed of their prospects.

The area which was originally owned by the Dun Mountain Copper-Mining Company has lately been taken up and prospected by Mr. Newport. Mr. Cox reports that certain fresh discoveries have been made, but he considers that many of the deposits of copper which were known to exist have not received the attention which they deserve. He describes the different outcrops of copper ore, and concludes by stating that the Dun Mountain copper deposits appear to have been most lamentably neglected, doubtless from the impression, at the time the works were being carried on, that the chrome iron deposits would better repay any work expended on them, and when the price of chrome fell the capital of the company was exhausted, and no further works could be carried on. He considers the surface indications here better than in any other part of the field.

AURIFEROUS REEFS.

Mr. Cox has made an examination of the auriferous reefs which have been found in the Wairarapa district, and of which he reports that Brandon's Reef, the one from which a ton of quartz was sent to the Thames, is situated about sixteen miles from Featherston, along the border of the Wairarapa Lake, and can be reached with ease. The drive has been put in along the strike of the reef north and south on the hanging-wall, and from the bottom of a shallow shaft a cross-cut has been entered, cutting through a leader about 2 feet thick, and then, after passing through a narrow belt of slate, the main reef is struck, but up to the date of his report this reef had not been driven through; it is, however, not less than 6 or 7 feet in thickness. The specimens brought from the reef yielded 14 dwt. 1 gr. and 12 dwt. 1 gr. of gold per ton respectively.

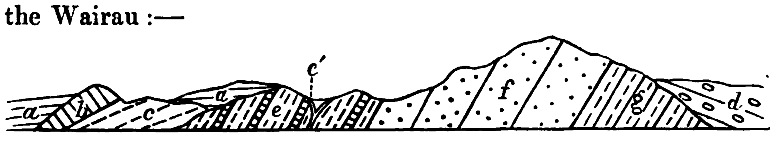
There are several other reefs in the district, and these have been found on assay to contain a little gold, from 4 dwt. to 8 dwt. being about the usual amount.

The course of the reefs is well marked, and they can be traced from the old Pioneer Claim in Palliser Bay in a northerly direction through Brandon's Reef (the old Galatea), and from there on through the flanking ranges of the Wairarapa Lake; and throughout the entire distance they are in easily accessible positions.

Longwood Range Gold Field.

This district was visited in March, on account of discoveries of very rich auriferous reefs having been reported. Gold-mining has been carried on in various localities round the base of the Longwood Range, and within easy reach of Riverton, ever since 1863, but in a very intermittent manner. At first the diggings were all alluvial, and these were reported on by me in 1868 (Progress Geological Reports, 1868–69, p. viii.). Even at that time prospecting was being carried on for reefs; but it is only within the last few years that any decidedly favourable results have been obtained.

The general structure of this auriferous district can be best explained by the following diagrammatic section across the Longwood Range, from the Jacob River Plain to the Valley of the Wairau :—



Section through Longwood Range.

II. *a.* Upper Tertiary clays.
IV. *b.* Vesicular basalts of Mount Pleasant.
c. Sandstone.
VI. *d.* Coal formation of Orepuke.
XII. *e.* Greenstone slates and breccias.
e′. Quartz leaders in the decomposed rocks.
f. Syenites.
g. Siliceous slates.

The mass of the range belongs to the Te Anau series (Upper Devonian), consisting in its higher and western parts of siliceous slates, interbedded with coarsely-crystalline syenite, with large crystals of hornblende similar to the Bluff Hill, and intersected as there by dyke rocks of various character.

Flanking the syenites along the south-east part of the range, and extending to Howell's Point, are greenstone slates and breccias passing into coarse conglomerates made up of sub-angular fragments of brown and green porphyry, cemented by a matrix of porphyritic greenstone, which contains crystals of hornblende; also various felstones, and a smooth-grained rock of a pea-green colour and porcelain-like fracture (aphanite), which is used by the natives for making meres, adzes, &c.

These varieties of rock, all of which are strikingly evident on the sea-shore, cannot readily be distinguished on the forest-clad slopes of the mountain, as the chemical nature of the rock has led to its decomposition to a great depth from the surface, so that the resulting gritty laterites and brightly-tinted clays are not readily recognized as being the same tough rocks in another form.

The quartz reefs occur in this decomposed rock, and are difficult to trace on account of the extensive superficial deposits. Although large masses of quartz occur in these drifts, only small leaders have as yet been discovered that are gold-bearing. In the locality I visited on this occasion, the leaders have been traced beneath an outcrop on the top of a spur by means of drives, and the indications obtained were considered sufficiently favourable to warrant the erection of machinery, which was then in progress.

Samples which I took from the quartz leaders which intersect the decomposed rock in a very irregular manner, and vary in thickness from a few inches to a foot, give very favourable results. A panful of rubbly quartz taken from the roof of the drive, weighing 7 lb., gave 21 grains of free gold by simple crushing, and the residue gave, upon thorough amalgamation, 99 grains more; thus giving a total yield of gold at the rate of 77 oz. per ton.

The chief difficulty in working this auriferous deposit will be due to the small size of the leaders, and the absence of any well-defined walls to guide the miners in following them; moreover, there will be a temptation to take out much of the enclosing and non-auriferous rock along with the quartz, which will not only increase the expense both in mining and milling, but I fear will probably lead to a great loss of gold on account of the large proportion of clay, which will interfere with all the amalgamating and other dressing processes that may be employed.

Adams's Reef, Mount Ophir Mine, at Collingwood, had just got to work when Mr. Cox visited the district. It is situated in Cole's Gully, and varies in thickness from 14 feet to 2 feet, it being from the pinched part of the reef that the richest gold has been obtained. The stone is very ferruginous, but has a white quartz running through it. It is exceptionally easily worked, and, if the returns are satisfactory, the mine should be successful.

The Mount Arthur Reef, the possession of which has formed a matter of dispute between two rival parties, Mr. Cox reports to consist of four distinct leaders, cropping out in the course of the left-hand branch of Gridiron Creek, which falls into the Takaka River, and is most easily reached from the Graham River. These leaders are striking north-east and south-west, with an underlie to the south-east. They have been bared for a short distance, and one or two other outcrops of quartz have been found lower down the creek, the course of which the reef appears to be taking. The quartz contains a great deal of iron-pyrites, sometimes at least 50 per cent., besides other minerals in smaller quantities, such as galena, pyrrhotine, zinc-blende, and copper-pyrites; and, when burned, gold is generally visible in hand specimens. The specimens forwarded for assay yield 2 oz. 5 dwt. of gold per ton. It is interesting to note the occurrence of gold in the Devonian rocks of the Te Anau series, in which this reef occurs, this being the first instance in this district of auriferous reefs being found associated with them.

COAL.

Specimens of coal from the Paringa River, Westland, have been forwarded by Mr. Macfarlane, by whom it is reported to be from the outcrop of what appears to be an extensive deposit of that mineral, one of a series of valuable seams found in the back country commencing at the Paringa River north, and extending south to the Moore River, near the Haast, a distance of some thirty miles along the coast by about eight miles wide. The seam appears to dip to the west, and shows about 12 feet of coal and fireclay, and it could be worked by open adit-level similarly to the Brunner Mine, near Greymouth.

The outcrop has been traced for a distance of three or four miles. The height of the part of the seam seen is (by aneroid reading) 465 feet above the sea-level, the top of the range itself being about 2,500 feet. As larger pieces of floating coal were found at a higher level than that of the outcrop in question, there are doubtless other seams above.

When analyzed, it proved to be a valuable bituminous coal, greatly resembling that from Ngakawau, Nelson, also some of the Pakawau coals. It is rather fragile, but homogeneous and pretty free from sulphur; water very low, and ash somewhat over the average of that of such coals generally. Its coke is highly vesicular, and so will not bear transit with impunity. Ash white.

Analysis.

Fixed carbon	63·46
Hydro-carbon	26·73
Water	·97
Ash	8·84
	100·00

Evaporative power, 8·2 lb.

As the coal is worked from the outcrop, there will doubtless be a considerably less proportion of ash in its composition.

The existence of the coal measures in this locality has been known for some time, and Mr. Docherty forwarded samples of coal from the Abbey Rock many years ago; but this is the first account of a workable seam being struck, those previously known being seldom more than 1 foot in thickness.

Besides the specimens collected from the above localities, a large and interesting collection of minerals and rock-specimens has been made from the Wakatipu District by Mr. McKay, who was employed in running detailed sections through that part of the country west of the Wakatipu Lake, in continuance of what was done last year in that district by Mr. Cox and myself.

Amongst others may be mentioned specular iron ore, magnetite, pyrrhotine, rhodonite, copper-pyrites, chromite, a very rare chromium mineral (chrome mica), and scheelite; bearing out the statement which I made in 1864, that the country lying to the westward of the faulted area about Lake Wakatipu would, in all probability, prove to be highly mineralized.

The geological survey of the Auckland District from Whangarei south to Auckland has formed the most important part of Mr. Cox's work for the past year, this being undertaken in continuation of the previous work of the department in the northern part of the Auckland Provincial District.

I had previously* pointed out that younger Secondary rocks

* Progress Report, N.Z. Geological Survey, 1874, p. vi.

were represented in the Kaipara District, and Mr. Cox has now succeeded in proving the existence of still lower beds of the same formation in the Upper Wairoa River, which cuts through soft sandstones with *Inoceramus*, &c.

Besides these, beds of Cretaceo-Tertiary age occur in the Kaipara Harbour, and at Komiti Point are overlaid unconformably by sandy marls and grits, over which are tufaceous sands and concretionary greensands. These beds, which are the same fossiliferous beds which I discovered in 1874 at Komiti Point, he classes together, and considers to be the same as the fossiliferous grits at Cape Rodney, and the equivalents of the Waitemata series; but *Pecten pleuronectes* and many Orakei Bay fossils being found at Komiti Point only in the marls, whereas the tufaceous beds are associated with a great preponderance of Lower Miocene forms, this rather bears out the view that the Waitemata series must be divided at the horizon of the Parnell grits. It is only right to state, however, that it is not altogether on the occurrence of these fossils, but rather on stratigraphical grounds, that Mr. Cox has placed these two sets of beds in the same horizon; and if this view is borne out its bearing on questions concerning the distribution of coal in the North is most important.

RECENT AND PLEISTOCENE.

Some interest attaches to this formation, at the base of which are seen consolidated sands with which are associated heavy beds of an inferior lignite, in all stages from wood to the more carbonized form. This lignite contains quantities of subfossil kauri resin, and is probably the equivalent of the oldest and deep-lying deposits of kauri gum which have of late attracted attention.

PLIOCENE.

These beds, which consist of scoria streams and craters, are best studied around Auckland, where they are resting on the Waitemata series. They also occur at Mount Tauhoa and Mount Maungatipu on the Wairoa River, and around Whangarei occupy a considerable extent of country. They consist of a number of extinct volcanoes, the craters of which are more or less perfectly preserved. Round Auckland the most noticeable feature is the scoria, but there are also various streams of basaltic lava which are quarried for building purposes; but these rocks have been so thoroughly described and mapped by Dr. von Hochstetter as to need no further remark at present. Further north where these rocks occur they are far less frequently found in this scoriaceous form, but occur as basaltic flöes, and form, at times, plateaux of considerable extent.

LOWER MIOCENE.

The strata included in this formation by Mr. Cox present a marked exception to its character in other parts of New Zealand, where it represents a period of great depression, and an absence of any evidence of that volcanic activity which is so marked a feature of the Upper Eocene formation. The highest beds of the series—the trachydolerite breccias—occur at the Manukau Heads and stretch northwards along the coast to Muriwai, where they strike inland, and, crossing the railway-line between Waimauku and Rewiti, pass on in the direction of Kaukapakapa, a further development being met with again further north on the western side of the Kaipara Harbour, where they are capping the greensandstones. At the Manukau Heads they overlie the Upper Waitemata series quite conformably, the top beds of that series containing pebbles and grains of volcanic rocks of a similar character: indeed, in many cases they are truly ash-beds. There is no stratigraphical break between these and the inferior Waitemata marls and sandstones as developed about Onehunga, and again in the Waitemata Harbour, in which latter place volcanic ashes are interstratified with and dispersed through the higher beds, while in the Kaipara district they pass down into concretionary sandstones, and thence to black marls with gritty beds at their base, in which, at Cape Rodney and Kawau, fossils are very plentiful, and, from their mixed character, indicate an intermediate horizon between the Mount Brown and Pareora beds of the South Island.

UPPER EOCENE.

The beds referred to this horizon are certain limestones and grits which occur up the Pahi arm of the Kaipara Harbour, where they are standing vertical, and are overlaid unconformably by the greensand marls of the last-mentioned series. They are probably the equivalents of the Papakura and Upper Raglan limestones, and are widely distributed on the eastern coast, occurring, however, only in patches, and resting in places unconformably on the Upper Cretaceous coal measures, and on the slates, as for instance at Morrison's Caves, Waipu.

CRETACEO-TERTIARY SERIES.

These beds form two natural groups, although all part of the same formation, viz., the chalk-marls with associated hydraulic limestones and firestone, and the greensand beds with which are also associated other limestones, and at the base of which at Whangarei and the Bay of Islands the coal occurs. The chalk-marls and associated rocks appear to be confined to the south-western side of the slate range which extends from Mangawhai North Head through the Tangihua Mountains, while, with one exception at Pahi, the occurrence of the coal rocks at the surface is reserved for the north-eastern side of the range.

The hydraulic limestone is being burned for the manufacture of cement at Mahurangi, some very good results having been obtained. Deposits of bog iron ore are of frequent occurrence associated with these beds, and indeed small lapilli of ironstone are scattered over the surface in almost every locality where the formation occurs.

LOWER GREENSAND.

Beds which are probably of this age are seen at Wilson's Landing, on the Wairoa River, below Tangiteroria, forming a large part of the floor of the Wairoa Valley. They consist of micaceous quartzose sandstones and olive-coloured shales, and contain *Inoceramus* and a small *Pleurotomaria* (?). But fossils are by no means plentiful.

UPPER DEVONIAN.

These beds consist of clay slates more or less tufaceous in character, and associated with red and green breccias like those of the Te Anau series, in the Waipu Gorge. They occur at Whangarei, and north to the Bay of Islands, carrying deposits of manganese oxide at places; and they are found again forming the basement rock at Cape Rodney, Little Omaha, and Matakana Heads, cropping up again in Kawau and Great Barrier Islands, and in all probability being of the same age as the slates of Cape Colville Peninsula.

DYKES, BOSSES, AND TRACHYTE FLOES OF UNCERTAIN AGE.

Various dykes and bosses occur throughout the area examined, which may or may not be of less age than the hydraulic limestone through which they frequently appear. There are dykes traversing the trachydolerite breccias of the Manukau

Heads, which are of Miocene age; but in other localities their occurrence is generally at the junction of the hydraulic limestones with the overlying and unconformable Lower Miocene beds, so that their deposition might have equally well taken place against these bosses as that they should have been intruded subsequently to their deposition. The evidence is, however, slightly in favour of the theory that they were all intruded subsequently to the deposition of the Lower Miocene rocks.

During September Mr. McKay examined the section along the east bank of the Mataura River, with the object of ascertaining the precise position of the Mataura plant-beds, containing a fossil plant which I consider to be identical with *Macrotæniopteris lata* of Morris and Oldham.

This important fossil, which is found in connection with the coal fields of India, not having been found in any of the sections of the Jurassic strata examined in the Hokanui Hills during 1877–78, and the Mataura section not having been examined on that occasion, some uncertainty still remained as to the exact position of the Mataura plant-beds. Mr. McKay has now succeeded in showing that they overlie the lower part of the Flag Hill series, as developed in Flag Hill to the east of the Otapiri Stream, the fossils of the latter horizon being found a little lower in the section, and nearly a mile farther down the river than where the plants are found at the Mataura.

The fossils yielded by the strata which limit the plant-beds belong to a horizon not lower than the Lower Belemnite bed of the Flag Hill series: the collection made contains *Belemnites catlinensis*, fragments of an ammonite, and the large *Plagiostoma* found on the coast-line near the mouth of Catlin's River.

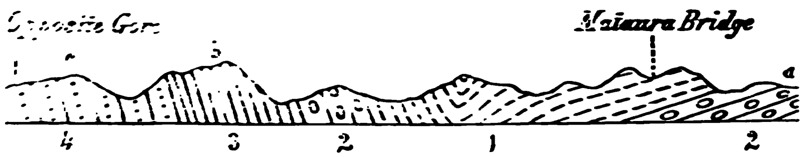
The other fossils, including *Pecten, Plicatula, Ostrea*, &c., are all found in beds 57, 58, of the Hokanui sections, as given in Mr. Cox's report on that district (Geological Reports, 1877–78).

This fossiliferous horizon is estimated by Mr. McKay to be not more than 200 feet under the horizon of the plant-beds: the latter should therefore occupy a position corresponding to the base of the Putataka series in the typical Flag Hill section. It is thus evident that no stratigraphical reason exists for distinguishing the Putataka from the Mataura formation, but the whole might be included as representing the Upper Oolite period under the latter name, which has the priority. It is, however, convenient to preserve the term Putataka for the marine and lower beds where they can be distinguished. The classification would thus be,—

Upper Mataura plant-beds.

Lower Mataura plant-beds = Putataka-marine.

On the east bank of the Mataura, the section between the railway bridge at Gore and a point four or five miles below the Township of Mataura was found to be in every respect similar to the sections across the eastern end of the Hokanui Hills, with the difference that the fossiliferous horizons are not so abundant. The general arrangement of the bed is shown in the following section :—



Section along east bank of Mataura River. 1. Mataura series (*Macrotaeniopteris* at base). 2. Flag Hill series (fossils at *a*). 3. Bastion and Otapiri series (fossils at *b*). 4. Wairoa series (fossils at *c*).

The plant-beds at the Mataura Falls are overlaid by a considerable thickness of estuarine strata, forming a syncline which crosses the Mataura River between the Falls and the Township of Gore. The position of the plant-beds thus determined has an important bearing on the question of the age of the relative coal-bearing strata in India and Australia, as I have already pointed out in my correlation of the formations of these countries. Coal-seams occur in these strata in the Southland District, as at Catlin's River, Waikawa, Otapiri, and the Seaward Downs; but, though excellent in quality, those as yet known are infinitely too thin and irregular to admit of being profitably worked.

CURIOSITY SHOP.

The examination of the "Curiosity Shop," a local name applied to an outcrop of arenaceous and calcareous strata on the banks of the Rakaia River, six miles below the Gorge, yielded a large collection of fossils, embracing some 2,500 specimens of Mollusca, Echinodermata, and Polyzoa. This collection is valuable for comparison with others from beds of the same age in the Trelissic Basin and near Oamaru. Amongst this collection are a few bones of the extinct giant penguin, *Palæeudyptes antarcticus* (Huxley), and numerous specimens of what appears to be the same fossil organism as that described by Professor Taitc under the name of *Belemnites senescens*;* but in this case there can be little doubt that this fossil is the spine of some form of *Cidaris*. A small but perfect example was obtained which measured 1½ inches in length, the greatest diameter being ·12 inch, cylindrical and slightly thorny, with both a radiate and concentric structure. At the base where attached to the tubercle there was no appearance of the bulbous termination common to most spines of Echinodermata, the end of the spine simply showing a shallow cavity. Large specimens are denser in structure, and in section become quadrate instead of circular. Some of the specimens collected could not have been less than 12 inches in length, with a diameter of half an inch.

The great feature of this collection is the abundance of Brachiopoda, one-half the total number belonging to this class. Most of the Gasteropoda and Lamellibranchiata are in the condition of casts, with the exceptions in the former class of the Turritellidæ and in the latter of the genera *Ostrea, Pecten, Lima,* and *Pinna,* of which latter only fragments have been obtained. On the contrary, all the Brachiopoda retain their tests, as also, generally speaking, do the Echinodermata.

Mr. McKay divides the strata into an upper and lower series—Nos. 2 and 3, and 4 and 5, of the section—and should

Section at Curiosity Shop, Rakaia Gorge. 1. Gravels of the Canterbury Plains. 2. Pareora beds. 3. Mount Brown or Hutchinson's Quarry beds. 4. Calcareous sandstones. 5. Grey sands.

his view, that the lower part of the section at this place is the representative of the grey sands forming the north-west slopes of the Harper Hills, between the Hororata and the Selwyn, prove correct, it may be of some importance as indicating the possible existence of coal-seams extending from the Malvern Hills across the Rakaia River a little higher up than the Curiosity Shop, although these seams would not be seen at the surface, the heavy gravels of the plains and the shingle of the river-bed alike obscuring them.

* Quart. Jour. Geol. Soc., May, 1877, p. 256.

A special visit was made to the West Oxford District, and the occurrence there of an important deposit of chalk has been proved. This deposit is reported to be not less than 100 feet thick, but at the time of Mr. McKay's visit no just estimate could be formed. Since then, Messrs. Ingram and White, on whose property the chalk occurs, have gone to some expense in laying it bare, with the view of ascertaining its extent and thickness. They report having cut a trench across its strike for a distance of six chains, but neither the upper nor the lower surface of the deposit appears to have been reached, so that the absolute thickness yet remains to be proved.

The samples of chalk obtained have more perfectly the mineral character and texture of English chalk than any previously discovered in New Zealand. The rock is pure white, fine-grained, and soft enough to be used for the manufacture of crayons.

Its composition, as determined by analysis, is as follows :—

Calcic carbonate...	82·26
Magnesic carbonate	1·84
Ferric oxide	Traces
Silica	15·69
Water	0·21
	100·00

Examined with the miscroscope, this chalk is found to be made up chiefly of minute shells of Foraminifera. The chalk from which the samples were taken crops out a quarter of a mile north-east from the north bank of the Eyre River, and eight miles from Oxford, at the upper part of a low bush-clad "edge" or ridge. It belongs to the Upper Cretaceous period, and is the local representative of the chalk-marl and Amuri limestone in the same formation further to the north. The overlying formation is volcanic, probably Middle Eocene, and the underlying formation is the concretionary greensand. The accessible position of the deposit, and the useful purposes to which it can be applied, render its discovery one of considerable importance to the community. The uses to which it can be profitably employed are as follow :—

1. *Manufacture of Crayons for the Use of Schools, &c.*—For this selected samples are admirably suited, the firm even grain and compact texture of the stone making it superior to most of

the chalk imported, and of which there is a large consumption in New Zealand and the Australian Colonies. The only other source from which chalk could be derived to compete with it, so far as yet known, is the group where the natives use a chalk deposit for carving rude and grotesque images, as lately discovered by Professor Liversedge, F.G.S.

2. As a manure to many kinds of land the chalk would be useful in its natural state, and owing to its friable nature could be profitably applied. Burnt into quicklime it would be useful for those soils which require a more energetic form of lime.

3. For the manufacture of whiting, which is a simple process of crushing and washing it into a fine sludge, which is collected in long troughs.

4. *For Mortar.*—The quicklime made from this chalk would probably not compete with that made from harder limestones, as it is more difficult to burn thoroughly.

5. *Portland Cement.*—This chalk should supply a very notable want in this colony. Cement is very extensively used, and on its good quality must depend to a very large extent the safety of many structures, especially in a colony liable to earthquakes. The imported cement is frequently very inferior, and in important works the sample tests that are made lead to the rejection of a certain percentage of the barrels, and it is obvious that it cannot be properly checked in this manner unless every barrel be examined. The attempts to manufacture cements hitherto from natural cement-stones have failed on account of the want of uniformity of composition, and when hydraulic or other limestones have been used in the attempt to manufacture cement the extra cost of crushing and twice burning prevents success. The best Portland cement, whether manufactured in England or Germany, is made from chalk similar to the Oxford chalk, mixed with clay in accurate proportions, dried, and then burnt almost to vitrification, and then ground to a fine powder. The success depends on the pureness and friability of the chalk, and the lowness of cost at which clay can be obtained in the condition suitable for mixing into a pulp with the chalk.

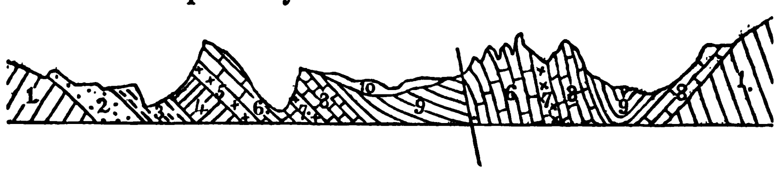
The convenience of this chalk deposit to the railway, and the ease with which it can be quarried, would allow of it being delivered at a low cost, and there is a capital supply of clay to be found on the slopes of the Port hills. The Malvern Hills would supply the coal, so that cement works established about Heathcote would have every advantage in their favour.

THE TRELISSICK BASIN.

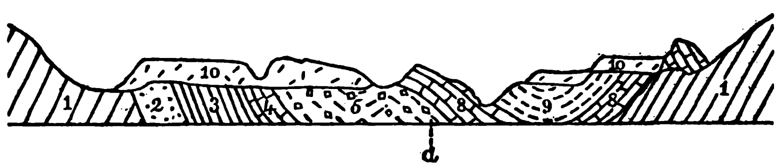
In connection with other work in the same neighbourhood, Mr. McKay re-examined the important outlier of the Cretaceo-Tertiary formation which occupies the Trelissick Basin.

Large collections were made, chiefly from the volcanic tufas which are interbedded between the Mount Brown and Weka Pass limestone horizons, and between the latter and the chalk-marls representing the Amuri limestone. The younger Tertiary rocks were also collected from.

While thus engaged, further detailed information respecting the stratigraphy of this most important and typical locality was collected, the sections in which, on account of their clear development, afford the most easily-deciphered and conclusive evidence respecting the succession of strata from Middle Cretaceous to Middle Tertiary, and from which it appears that the arrangement I proposed, after examining the district in 1872, is in the main correct, so that the map and sections made on that occasion are now published with the present report. The classification adopted may be best understood by reference to the following sections and explanatory notes :—



Section (1)—From east side of basin, across Prebble Hill and Castle Hill, to west side of basin. 1. Old Secondary and Palæozoic. 2. Coal-beds. 3. Greensands. 4. Chalk-marls. 5. Lower tufas. 6. Weka Pass stone. 7. Upper tufa (fan-coral bed). 8. Mount Brown limestone. 9. Pareora series. 10. Recent.



Section (2)—From Porter River along south bank of Whitewater Creek. 1. Old Secondary or Palæozoic. 2. Coal and greensand beds. 3. Greensands. 4. Chalk-marls=Amuri limestone. 5. Breccia and tufa beds. (a) Fossils. 8. Mount Brown limestone. 9. Pareora beds. 10. Recent and Pleistocene.

IV.—LOWER MIOCENE.

1. *Pareora Series.*

a. *Lignite Sands.*—These consist of thick green sandy marls, passing into grey or yellow sands, containing silicified fossil wood and a few casts of estuarine shells. They have been formed in a shallow estuary, and their thickness is variable and uncertain.

b. *Upper Marine*.—Fine grey sand and clay, with bands of gravel containing broken shells of *Mactra, Ostrea, Struthiolaria*, &c., generally forming hard cement-layers.

c. *Lower Marine*.—Fine sands, such as form off a shore-line, consisting chiefly of comminuted shells, with *Crassatella ampla, Turbo superbus, Pectunculus*, &c. *Myliobatis* and *Lamna* teeth also occur, but are probably washed from the next formation. These beds rest on a *Pholas*-bored surface showing a marked unconformity. This is a littoral formation about 500 feet thick.

V.—Upper Eocene.

2. *Mount Brown Beds*.

a. *Compact Calcareous Sandstone*, passing into sandy limestone that is cleaved and rendered subcrystalline at the Parapet Rock and the Hogback, and is wanting in some parts of this section. It contains an abundance of *Sargus* and *Lamna* teeth, *Pecten, Terebratula, Waldheimia*, and Echinoderms. It is often somewhat difficult to distinguish this formation by its mineral character alone from the Weka Pass stone, which belongs to a lower formation.

b. *Pebble Breccia*.—Contains fragments of black siliceous slate and volcanic rocks, with *Pecten athleta* and *P. hutchinsoni*. They are marine beds formed at a moderate depth, and about 300 feet thick.

3. *Hutchinson's Quarry Beds*.—Tufaceous sand, with *Cardium striatum*, and fan-corals (*Flabellum laticostatum*, Ten.-Woods).

As a local equivalent to these are igneous tufas and breccias, intersected by contemporaneous eruptive dykes. These beds vary in thickness according to the amount of volcanic material present: where that is in small amount they are represented by 40 feet of greensand and shell-breccia; but within short distances they expand to include 200 feet of chocolate tufas. Period of submarine eruption.

VI.—Cretaceo-Tertiary.

4. *Ototara Stone*.—This term is synonymous with the Weka Pass stone in other reports, and is a thick band of calcareous sandstone, which terminates an unbroken series of immense thickness extending from the Middle Cretaceous to the Middle

Eocene period. From an economic point of view, this is the most important formation in the district, as it yields the valuable Castle Hill building-stone. There are no fossils from this locality, and the thickness is about 100 feet.

5. *Lower Tufa Beds.*—The above beds rest on dark-coloured basic tufaceous marls and grey calcareous sandstone containing *Pecten zittelli, P. hochstetteri,* Echinoderms, and *Mytilus.*

6. *Chalk Marls.*—These are indurated marly shales of a light-grey colour, containing cherty bands and veins of calc-spar. They correspond in position to the Amuri limestone. Besides the large radiating fucoids which are so characteristic of this formation both at Cobden on the West Coast, Amuri Bluff, and elsewhere, fossils are rare, consisting only of minute *Pectens* and fish scales.

7. *Concretionary Greensands.*—These beds consist of brown sandy marls and bright-coloured greensands, with hard concretions of glance sandstones. The only fossils obtained from these beds are *Ostrea subdentata, Tellina,* and nests of retinite (fossil resin).

8. *Boulder Sands.*—These are identical in mineral character with the saurian beds of the Waipara and Amuri sections, and contain the massive black oyster-shell which, with *Conchothyra parasitica,* is so characteristic of this horizon. The thickness of these beds is 250 feet.

9. *Black Grit.*—This formation comprises sandstones with sulphur efflorescence, gritty greensands, and dark shales with coaly streaks, fossil tree-stems and silicified wood, together with *Lomarites* and other characteristic plants of the coal-bearing strata at Shag Point, the West Coast, and other places where coal-seams occur.

The older Secondary and Palæozoic rocks of the North Canterbury and Amuri Districts form the subject of a separate report, and are treated of at some length.

Oolite and Liassic Strata.—The subdivision of these formations into Mataura, Putataka, Flag Hill, and Bastion series which have been distinguished elsewhere, is not here recognized. From the Cairn Range, a collection of fossil ferns was obtained from strata which are of the same age as the Clent Hills plant-beds, and the equivalents of the Mataura sandstones of the Upper Oolite period.

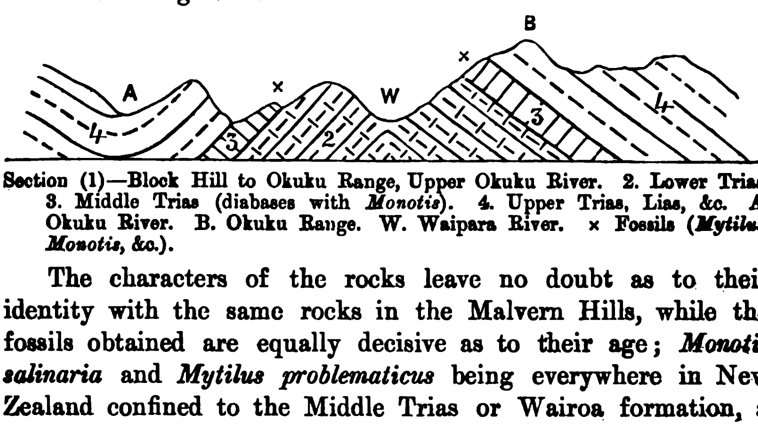
Mr. McKay does not believe that these beds are older than the diabases, cherts, and limestones which form part of the Four-

Points Range, and strike across the Selwyn Gorge to the northward; and, as these latter are now proved by the fossils obtained to be of Triassic age, the reference of the plant-beds in the Cairn Range to the Oolite period agrees both stratigraphically and palæontologically with evidence elsewhere obtained. The same beds form part of the Mount Thomas Range, between the Ashley and Okuku Rivers, and, west of Heathstock and the Horsley Downs, are developed on the south bank of the Hurunui River, and also at the Hurunui Bridge, on the opposite side of the plains. The same rocks form part of the Leslie Peak, between the Hurunui and Hanmer Plains and the southern slopes of the ridge leading to Jollie's Pass from the south-west side. They further form part of the strata present in the valley of the Alma River, and thence strike in the direction of the Upper Awatere River.

Otapiri Series.—The rocks of this series are taken to be those which immediately overlie the diabases, &c., this being the position of the beds at all points where they contain characteristic fossils. On the north-west side of the Mount Thomas Range a fossil Trigonia was obtained, the same fossil being found in the Otapiri series at Nugget Point, in the Hokanui Hills, and at the Wairoa Gorge, and passing downwards into the Wairoa series; but it is not found in younger beds. From the foregoing points the presence of the Otapiri series in the district may be argued.

Wairoa Series.—Several years ago I pointed out the presence of Triassic rocks in the Malvern Hills (Geological Reports, 1869, p. 47); and Mr. McKay, in 1874, referred the rocks of the Okuku Range further to the north-east to this period (Geological Reports, 1874, p. 42); but positive evidence bearing out the correctness of these determinations was not obtained till the present season. The facts now brought forward have a most important bearing, as they show that a very large surface-area of the more mountainous districts of Canterbury and East Nelson is covered by older Secondary rocks, as shown on the Geological Map issued in 1873. In a later map prepared this year for the Sydney Exhibition, these have been subdivided as Carboniferous, Permian, and Lower Secondary formations; but the boundaries yet require some revision.

Rocks comprising cherts and altered limestones occur in Southern Canterbury, which cannot well be regarded as other than palæozoic, and there thus arose a tendency to classify like rocks in the northern part of the provincial district as belonging to the same formation so long as the true stratigraphical position of them was not ascertained by the evidence of fossils. At the same time there was absolute proof of the occurrence of the Permian formation in the valley of the Rangitata River, and of Jurassic strata in the Clent Hills, Malvern Hills, and elsewhere, which there was no reason to suppose were confined to the immediate locality in which they were shown to be fossiliferous. Further, while personally satisfied that the diabases and limestones of the Malvern Hills were of Secondary age, it did not appear warrantable, without more direct evidence, to colour as Triassic a great part of the area which Professor von Haast had referred to the Lower Carboniferous period. Mr. McKay has now traced the diabases, cherts, and limestones of the Malvern Hills over a great extent of country both in Canterbury and Nelson, and, what is more important, has found the calcareous portion of this series to be richly fossiliferous in the hills lying between the Upper Okuku and Waipara Rivers. The relative position of the fossiliferous beds to the other formation is shown in the following section :—



Section (1)—Block Hill to Okuku Range, Upper Okuku River. 2. Lower Trias. 3. Middle Trias (diabases with *Monotis*). 4. Upper Trias, Lias, &c. A. Okuku River. B. Okuku Range. W. Waipara River. × Fossils (*Mytilus*, *Monotis*, &c.).

The characters of the rocks leave no doubt as to their identity with the same rocks in the Malvern Hills, while the fossils obtained are equally decisive as to their age; *Monotis salinaria* and *Mytilus problematicus* being everywhere in New Zealand confined to the Middle Trias or Wairoa formation, a large collection of perfect specimens of which have been obtained from the Upper Okuku River.

Fortunately, associated with the fossiliferous beds is a strong development of diabasic ash and amygdaloidal tufas, together with certain intrusive rocks. These rocks, forming a distinct and unmistakable horizon, were traced from the Malvern Hills west across Mount Torlesse and along the intervening ranges to the source of the Cass River, where they suddenly terminate by abutting against older strata. Forming a syncline here, the line of outcrop is again carried back to the eastward and to the north-east, along the north-west side of Mount Thomas Range to the gorge of the Okuku River; thence they strike north-west and west across the country near the source of the Ashley; and another outcrop goes to the east in the direction of Mount Grey. In the hills west of the Horsley Downs they are found striking north-east across the Hurunui, and in this direction it would appear as though they formed a syncline carrying younger rocks. In Nelson they have been traced from the north side of the Hanmer Plains along the range between the Alma and Acheron Rivers to their junction. A line further to the west again has been traced from the mountains between the Awatere and Wairau Rivers along the latter to the junction of the Rainbow River, and this line, there is some reason to believe, is continued south-west along the Spencer Mountains to the Upper Waiau-ua, and it may also be present in the Mytholm Mountains, between the Waiau-ua and the Hurunui Rivers.

As these diabases form the upper members of the Wairoa series, the associated underlying strata must be considered as belonging to that formation, and, from their extensive outcrops, it cannot be doubted that a great extent of country is covered by the formation.

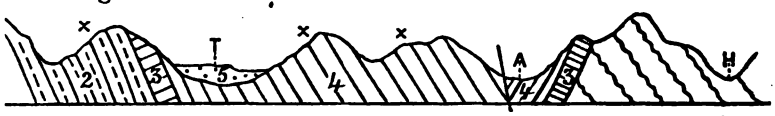
Permian Rocks.—No palæontological proof of the presence of these rocks was obtained; but there is reason to believe that they are present near Arthur's Pass in the Upper Waimakariri Valley, and at other places where a great thickness of strata conformably underlies the diabases of the Wairoa formation.

Maitai Series.—Mr. McKay proposes to distinguish these as the Annelid beds and the Maitai slates.

Annelid Beds.—These rocks are referred to the Middle Carboniferous formation as developed in New Zealand. They are not largely developed within Canterbury north of the Rakaia River, being as far as yet known confined to the ranges north-west of the Malvern Hills, between there and the Acheron River; an isolated outcrop occurs at Gorge Hill, on the Waimakariri River, and a narrow strip along the borders of the plain from Oxford across the Ashley Gorge to Glentui Creek.

According to Mr. McKay they have an important development farther to the north-east, where they form the great bulk of the Kaikoura Mountains from the Upper Awatere in a south-west direction.

There appears to have been hitherto some confusion as to the identification of this very indefinite fossil, and as to the precise beds which yielded it, and this has led to some confusion in the geology of a very large area in the South Island. The following section illustrates the relations of these beds :—

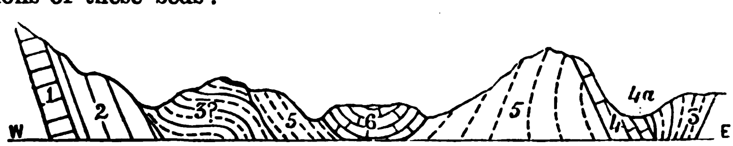


Section (4)—Mountains west of Tarndale, across Alma Valley to Acheron River. 1. Annelid beds. 2. Lower Trias. 3. Middle Trias (diabases with *Monotis*). 4. Upper Trias, Lias, &c. 5. Recent or Pleistocene. T. Tarndale Flats. A. Alma River. H. Acheron River. × Fossil plants.

Maitai Slates.—These were only seen east of the main range between the Cass River and the Upper Waimakariri Valley. To the westward the green slates of the Maitai series appeared to be underlaid by sandstones and shales, with beds or nests of compact limestone, from which fragments of the Dun Mountain *Inoceramus* were obtained.

During the latter part of January last, Mr. McKay examined the Motunau District, principally with reference to a reported discovery of coal there. While the particular seam examined proved of no great value, it appears that there is yet a probability of workable seams being found, although, until the district has better means of communication than at present, these can only be valuable for supplying local wants.

The coal measures at Motunau are of the age of the Malvern Hills coal field, and the quality that of the average coal from the latter district. The area of coal-bearing rocks is divided into two basins by a ridge of Triassic strata known as the Wedder Hills or Lambing Run; that to the south-west, or in the valley of the Motunau River, being of the greatest extent, besides containing the thickest seams. The following section shows the relations of these beds :—



Section (4)—Across south branch of Motunau Creek. 1. Middle Trias (diabases). 2. Otapiri series (?). 3. Coal-beds. 4. Amuri limestone. 4*a*. Oyster-beds. 5. Grey marls. 6. Mount Brown limestone.

The beds which overlie the coal contain numerous large septaria, in many of which fossil wood and occasionally saurian remains occur. *Mauisaurus haasti* and *Plesiosaurus crassicostatus* have been identified as present in these boulders; and another species also occurs, which may be *P. australis*, but this is less certain.

In places the sequence is complete from the coal-beds to the Amuri limestone; but nowhere, as far as this district was examined, was the Weka Pass stone found. The grey marls appear to follow the Amuri limestone, and, in places, to be interstratified with the upper softer and chalky portions of that deposit. The younger strata of the district rest indifferently upon the various members of the coal series, from the Teredo limestone upwards to the grey marls; but in the northern area they keep to the seaward slope of the coast range.

In the south-west end of the coal area, in the Upper Motunau, the Mount Brown and Pareora beds are present, and also on the northern end of the Mount Cass Range. The coal and saurian beds are continued south-west along the north-west side of the Mount Cass Range to the upper end of the Waipara lower gorge, having the Amuri limestones both to the north-west and south-east.

The beds forming the western side of this anticline, as they approach the Waipara, dip under the gravels and other alluvial deposits of the plain; but their presence has lately been proved beneath the shingle of the Waipara River bed, in sinking the piles of the railway bridge. A syncline is thus formed between here and the Weka Pass, although the higher rocks seen on the north-west side of this have all a south-east dip, and are absent from the opposite side of the syncline.

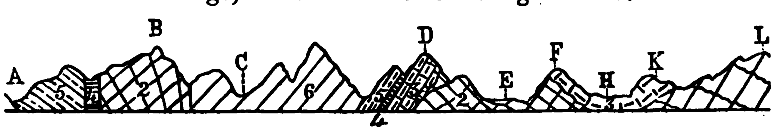
From the 1st February to the first week of April Mr. McKay was engaged in an examination of Lake Wakatipu, and the district west to the Hollyford Valley.

As a great deal of unfavourable weather was experienced during this trip it proved impracticable to carry out his instructions to the letter, but in spite of this drawback many valuable observations and a large collection of rock specimens were made. In the western part of the district the lower western slopes of the Lake Harris range were ascertained to be formed of aphanite breccias, sandstones, &c., belonging to the Upper Devonian period (Te Anau series). Between the Greenstone Saddle and Lake Harris, these beds have a very narrow exposure on the east side of the valley, but are supposed to cap the higher eastern slopes of the Darran Mountains; but this point has not yet been settled by actual observation.

The deep narrow valley of the Hollyford (Kakapo River), here but little more than half a mile wide, has cut through the breccias dipping east, till along the lower eastern slopes of the Darran Chain the crystalline schists of the West Coast sounds are exposed as a light-grey rock, occupying the first 1,500 to 2,000 feet of the mountains on the west side of the valley. Higher than this the rocks change to a darker colour, and have a tendency to form, in favourable places, beds of shingle. In the cross sections exposed in the sides of the larger valleys cutting back into the range, this upper rock is seen to be highly unconformable to the underlying crystalline schists. To the south of the Greenstone Saddle the Te Anau breccias extend along the eastern borders of the crystalline schists in the direction of the head of Lake Te Anau, and they form the last shore of Gunn's Lake. To the north they gradually encroach upon the Lake Harris Range, till at the northern end they rise to an elevation of 5,000 feet, and beyond this the Te Anau series forms the whole of the Bryneira Mountains; the valley of Pyke's (Waiwaka) Creek, in which Lake Alabaster (Rotowaiwaka) lies, being on an eroded anticline of these rocks, the west side of which forms part of Skipper's Range.

The highest beds of this series are subcrystalline limestones, interlaminated with fine-grained aphanite breccias. To the east they are bounded by a belt of serpentine, the great mass of which is an intensely dark-green rock, and within this belt there is a variety of crystalline rocks.

From Red Mountain to the Greenstone Pass, the serpentine separates the aphanite breccias from the schistose rocks of the Lake Harris Range, as seen in the following section:—



Section (1)—From Hollyford Valley, across Lake Harris Range and Humboldt Mountains, to Richardson Mountains. 1. Crystalline schists. 2. Foliated schists. 3. Lake Harris schists. 4. Cecil and Walter Peak series. 5. Serpentines. 6. Te Anau series. A. Hollyford Valley. B. Lake Harris Range. C. Upper Route Burn. D. Upper Peak. E. Dart River. F. Mount Alfred. H. Rees River. K. Precipice Hill. L. Richardson Mountains.

The higher central part of the Lake Harris Range is composed of highly crystalline schistose rocks, grey, green, and red, which strike north and south, and have a high dip generally to the east. These rocks form a syncline between Lake Harris and the lower part of the Route Burn, and extend along the main range as far as the Bean Burn Saddle. In this syncline rest the younger rocks belonging to the Te Anau series, comprising aphanite breccias and serpentines, followed by Maitai slates. The rocks of this syncline followed to the south gradually cover up the older rocks upon which they rest, till, south of the Greenstone River, the whole country from the shores of Lake Wakatipu to the source of the Hollyford in Gunn's Lake is formed of these newer rocks.

In the lower part of the Greenstone River their lower beds are seen dipping west; but to the south, near the mouth of the Von River, they dip to the east, and are suddenly terminated against schistose rocks, this junction probably being a line of fault.

A series of dark-blue silky slates and fine-grained metamorphosed breccias, which are distinct from and unconformable to the foliated schists forming the Forbes and Richardson Mountains east of the Dart Valley and upper part of Lake Wakatipu, form the south side of the east and west reaches of that lake, the lower slopes of the ranges at the head of the lake, the mass of Mount Bonpland, and rise high on the western spur of Earnslaw, striking thence up the valley of the Dart River.

The foliated schists have a uniform dip at high angles to the south-west, or in the north part of the district to the west, and these rocks form the country east far beyond the boundary of the district examined. They are composed of alternations of grey quartzose schists with thicker-bedded chlorite schists and bands of quartzite, with which are several alternations of soft blue mica-slate, that are sometimes talcose. As I have previously pointed out, it is along these talcose slates that the chief gold-workings of the district are found.

From the north shore of the cross-bend of Lake Wakatipu, and extending thence along the eastern slopes of the Richardson Mountains, a great fault appears to have thrown the strata down to the eastward. This is evidenced by the presence of younger and unaltered rocks along this line, and not only Tertiary and young Cretaceous rocks are involved in this faulting, but also aphanite breccias belonging to the Te Anau series and of Devonian age.

The Eyre Mountains, separated by Lake Wakatipu from direct continuation with the Richardson Mountains, are formed of the altered breccias above described, which are set back, as it were, in the line of the Richardson Mountains, so that there is probably another fault running parallel with the east-and-west or middle bend of Lake Wakatipu. We have thus evidence of three distinct lines of fault which conform to the direction of the bends of the valley partly occupied by Lake Wakatipu, so it is probable that these have exerted some influence in directing the erosive action by which it was excavated. These fault-lines require further study, but the following are somewhat their arrangement and characters :—

1. Along the west side of the upper bend, and continued south past the mouth of the Von River, and through Mount Nicholas in the direction of the source of the Oreti River, having the downthrow on the west side.

2. That along the east side of the Richardson Mountains, which may have had to do with the origin of the south bend of the lake. In this case the downthrow is on the east.

3. An east-and-west fault along the line of the Kawarau River and the east-and-west reach of the lake, with the downthrow on the south side.

The date of these movements is certainly young Tertiary, and yet before the date of the great extension of the glaciers in the mountains of the west part of the district. With reference to the causes of the former extension of the glaciers and the share these may have had in the formation of the basin of Lake Wakatipu, the present physical conditions of the western part of the district distinctly point to the former existence of a high plateau or table-land twenty-five to thirty-five miles wide, into which the valleys of the larger rivers have eaten back till it has now assumed its broken form of surface, intersected by sharp ridges, with occasional lofty peaks, but quite incapable of carrying the amount of perpetual snow which occupied the same area at one time, feeding the glaciers, the former greater extension of which is proved by the widely-distributed moraines and the surface features of the country.

JAMES HECTOR,

Director.

GEOLOGICAL REPORTS, 1879–80.

ON CERTAIN MINES IN THE NELSON AND COLLINGWOOD DISTRICTS, AND THE GEOLOGY OF THE RIWAKA RANGE.

REPORT BY S. HERBERT COX, F.C.S., F.G.S., ASSISTANT GEOLOGIST.

INSTRUCTIONS BY DR. HECTOR.

I WISH you to proceed to Nelson and visit Mr. Hacket's copper mine in Aniseed Valley. You will pay particular attention to the conditions under which the so-called copper stratum occurs, noting its relation in strike, dip, &c., to the mineral belt; the extent to which it has been proved; and the facilities which exist for working.

You should also visit the other outcrops of copper ore in the district where mines have been opened out, and furnish a report on their general capabilities as regards position, facilities of working, and probable extent.

I also wish you to visit Collingwood and examine the auriferous reef lately discovered there; and also, in the limestone belt on the Parapara River, endeavour to trace the belt of ironstone reported by Mr. McKay last year in the Mount Arthur District.

By going overland from Nelson to Collingwood, you will have an opportunity of determining the position occupied by the foliated schists between Motueka and Parapara, also collecting a fresh series of rock specimens, especially from the garnetiferous schists which occur on the summit of the track.

1st August, 1879.

NARRATIVE.

I HAVE the honor to inform you that, in accordance with your instructions herewith appended, I left Wellington for Nelson on the 10th October, arriving there next day. I was engaged in the examination of Mr. Hacket's copper stratum until October 15th. On the 16th I visited the Roding River Mine, and on the 17th the Dun Mountain, where I examined the various deposits and workings as far as practicable. On the 20th October I visited the Aniseed Valley Copper Mine; and on the 21st I left for Motueka, passing over the Riwaka Range to Takaka on the 22nd. On the 23rd I visited the Waingaramumu and Motupipi Hills, and, leaving Takaka the next morning, arrived at Collingwood the same day; and on Saturday, October 25th, I visited Bedstead Gully. On the 27th I went to Richmond Hill, and on the 28th to Cole's Creek and the Mount Ophir Mine, returning to Takaka on the 29th, and reaching the foot of the Riwaka Range on the 30th. On the 31st October I passed over the range to Motueka, and paid special attention to the relations of the beds which I had noticed on my way over; and, leaving my horse at Motueka, I reached Nelson by steamer on Saturday, November 1st. On the 3rd November I returned to Motueka and went from there to the Graham River, where I stayed for the night, reaching the Mount Arthur Reefs in Gridiron Creek the next day; and on the 5th I returned to Motueka, arriving in Nelson on the evening of the 6th. On the 8th of November I left Nelson for Auckland, arriving there on the 11th.

REPORT.

In reporting on the various points which I was instructed to examine in the Nelson and Collingwood Districts, it will, I think, be as well to give the geological features of the country first, and then pass on to the special mention of those mines which I visited.

The accompanying plan and sections of the Riwaka District, which I was specially instructed to examine, show the results of my work; but, since the maps which can be obtained are of the most primitive character, the boundaries shown can be nothing more than approximately accurate.

The general results of my observations are as follow:—

Immediately on commencing to ascend the range from the Riwaka side, granites are met with which extend to Adele Island, and thence to Separation Point. Above these granites fine-grained mica-schists, very rotten on the surface, are exposed, and these gradually give place to hornblende-schists and porphyries. These, or similar rocks, Mr. McKay has considered as intrusive in character; but I confess that their mode of occurrence rather leads me to look upon them as metamorphic rocks, possibly owing their metamorphism to the same cause which changed the limestones next to be mentioned. They are varied in character, at times being composed of large crystals of hornblende in a quartz matrix, while at other times they consist chiefly of hornblende, but in smaller crystals. They extend for about two miles on the track, which is crossing the general strike of the rocks, before the limestones appear, and these limestones extend uninterruptedly until the main ridge of the range is reached, where the schists come in and compose the entire extent of this main ridge.

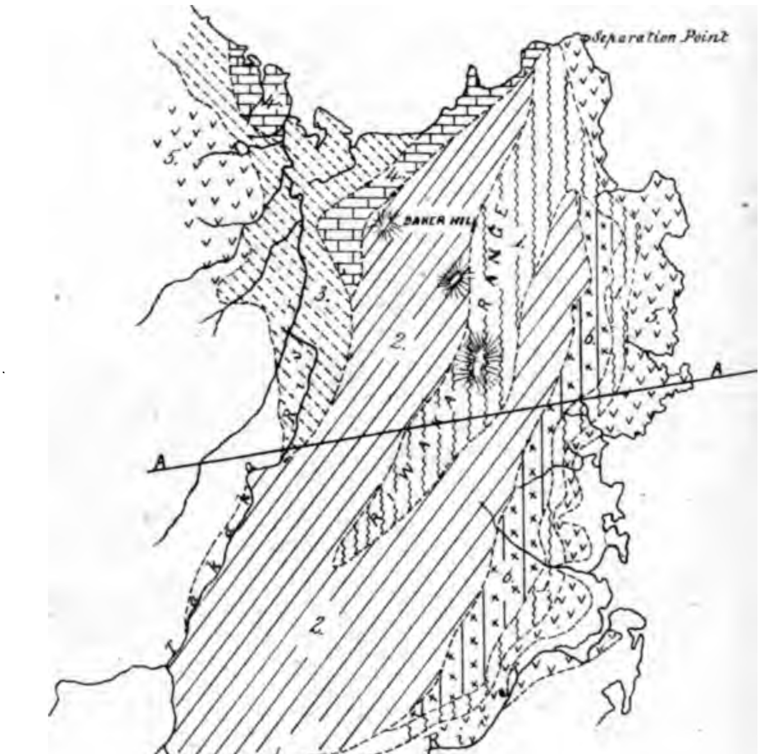
The limestones are white and crystalline on the east side of the belt, and form as good samples of marble as any I have seen from Pakawau, but are inferior in quality to those obtained from Caswell Sound last year. They are striking north-north-east, and dipping east-south-east, at angles varying from 60 degrees to almost horizontal, and in their strike correspond to the schists below them; I have little doubt, however, that the main body of the lime-

Geological Survey of New Zealand.

JAMES HECTOR, C.M.G., F.R.S., DIRECTOR.

SKETCH MAP OF RIWAKA RANGE

TO ILLUSTRATE REPORT BY S. H. COX.



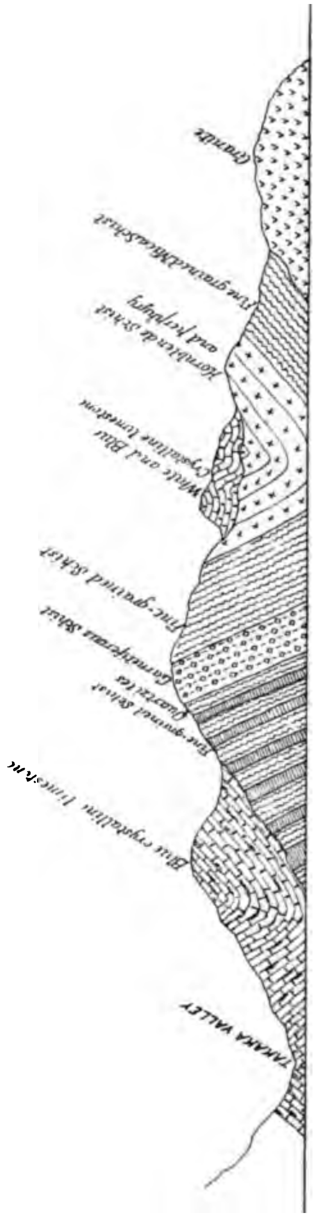
Reference
1. Garnetiferous and Fine grained Mica Schist
2. Blue and white Crystalline Limestone
3. Grey marls (Cretaceo-tertiary)
4. Tata Island Limestone
5. Granite
6. Hornblende Schists

Geological Survey of New Zealand.

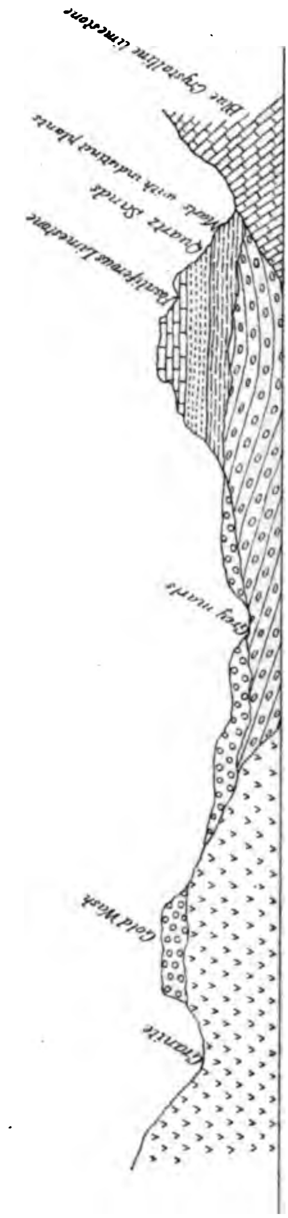
JAMES HECTOR, C.M.G., F.R.S., DIRECTOR.

SECTIONS IN THE RIWAKA DISTRICT

TO ILLUSTRATE REPORT BY S. HERBERT COX.



SECTION AA. THROUGH RIWAKA RANGE



SECTION ACROSS TAKAKA VALLEY

stone is unconformable to the schist, although thin belts of a similar stone occur which are undoubtedly interbedded with them. At various points after entering the limestone belt outcrops of the hornblendic rocks, mentioned above, are met with, from which I have inferred their extension as shown in the section.

The schists of the main ridge consist of garnetiferous schists, interstratified with fine-grained mica-schist and quartzites, and here and there traversed by quartz veins. These are passed out of on the western side of the range directly the main range is left, the flanking ridge being composed of blue crystalline limestones, which extend down to the base of the range, and on this side they have an east-south-east strike, a certain amount of evidence in favour of unconformity being thus gained.

Farther down the valley of the Takaka grey marls are seen at various places, and they no doubt cover the greater part of the flats, and extend as far as Collingwood, since they can be seen in the cliffs along the sea-beach as well as at various places inland. They are overlaid at places, as, for instance, on the east side of the Takaka River from near Abbott's accommodation-house to Tata Island, by a shell limestone, with quartz sands and marls with indistinct plants below; but there must be an unconformity between these beds and the grey marls.

The limestones occur again in the headland west of the Takaka River, and appear once more near Collingwood, at the Devil's Boots, stretching from there to the caves, besides which they also occur on the west side of the Aorere River.

The recent deposits of the Takaka River of course obscure the grey marls over a considerable area, and the terraces which mark the different levels at which the river has flowed from time to time, further hide them.

The gold drifts, which are chiefly these old terraces, appear to rest, where they are being worked for gold, chiefly on granite, as, for instance, at the Waingaramumu diggings, and the granites extend up the creek as far as I went.

I have not attempted to show upon the appended map the reefs, &c., of the Collingwood District, and, indeed, there is a good season's work in laying down accurately what is known of the various ore deposits there.

A large body of ironstone occurs interbedded with the limestones in the bed of the Parapara River, and is, in all probability, the back of a heavy pyritous lode; but nothing can be done to prove this without a considerable amount of work. I mentioned in a previous report the occurrence of a reef of pyrites in the bed of the Parapara River above McGregor Creek, and I think it is very probable that this also will prove to be of similar character.

I shall now pass on to review the various mines in the districts which I visited during the course of my trip.

JOHNSTON'S COPPER STRATUM.

During the early part of my trip I visited the outcrop of metallic copper in Aniseed Valley, known locally as Johnston's Copper Stratum. The ore in question consists of a granular serpentine, through which metallic copper is disseminated in minute grains, and this ore, as tested in the Colonial Laboratory, has been found to yield from 2 per cent. to 6 per cent. of copper. The outcrop of this ore was first discovered by Mr. Johnston at a short distance above Mr. Hacket's old chrome workings, and at this place a trench has been cut for a short distance, and some hundredweights of the stone removed.

On the south-west side of the cupreous deposit, a bed of white elvanite occurs some 6 feet in thickness, and the copper is not to be traced through this: however, at a short distance further to the south-west it has again been picked up, and further discoveries have been reported to the south-west of this point, although the discoveries in question relate only to loose pieces of ore which have been picked up on the surface, and, so far as I can make out, no regular outcrops have as yet been found. In a north-easterly direction similar results have been obtained, and Mr. Newport informs me that he has found boulders of the stone on the Dun Mountain property.

The country in which this ore has been found consists of soft green serpentine with hard included masses of dunite-porphyry, diallage rock, and elvanite, which are very irregular in their disposition and size, but follow the general course of the mineral belt north-east and south-west.

Apparently obeying the same rule as the above-mentioned rocks, the granular serpentine with copper occurs, and it has yet to be shown of what extent this deposit may be, since, up to the present time, it has not been traced for any great distance.

The points which appear to be the most worthy of note in connection with the deposit are these:—

1. The copper is very regularly distributed through the stone where it has been found, and would probably contain upon an average about 5 per cent. of metallic copper.

2. It occurs on the north-west side of the mineral belt in the same line of country as all the other copper and chrome deposits which have yet been found, and, like them, it appears to follow the line of the mineral belt.

3. It is associated with elvanite, a rock which occurs in connection with the copper deposits at every point from Aniseed Valley to D'Urville Island, so far as I have seen.

It would be quite premature to speak of the prospects of this deposit, considering how little has really been done to open it up, and so I have confined myself to describing the exact mode of its occurrence. If when the deposit is opened up it is found to be of any extent I have no doubt that it could be worked to a profit, but it is necessary, in the first instance, to show that the ore exists in sufficient quantities to pay for working.

Since writing the foregoing report I have visited the Serpentine River, lying south-west of the outcrop of serpentine with metallic copper in Aniseed Valley, and find that a similar rock is occurring there *in sitú;* but, while the truly bedded character of the rock is here more apparent than in Aniseed Valley, the quantity of contained copper is less than at that locality.

The Aniseed Valley Company's Copper Mine.

This mine is situated near the mouth of the Serpentine River, and the ore appears to be far more patchy than it is at other outcrops which I have visited, but it would also seem to carry better ore where the patches are good. At present I do not consider the deposit by any means well defined, for the ore is only found in pockets, and, when these have been worked out, the appearance of the country gives no indication of copper. As, however, these patches have up to the present been pretty frequent in their occurrence, there is a certain amount of encouragement to proceed with the work of the mine in the hope that a larger deposit may yet be met with.

But very little money has hitherto been expended here, and consequently but little can be seen; and, when I visited the mine, operations were suspended until a fresh contract should be let for further sinking the shaft.

Roding River Mine.

In the case of the Roding River outcrop no very decided results appear so far to have been gained, but an outcrop of ore has been found, and a trench cut to intersect the ore-band at a depth of about 20 feet below the outcrop. A tunnel has also been put in from the Roding River side of the ridge, but has not, I understand, struck any ore as yet. I did not, however, visit this tunnel, and so cannot speak definitely on this point, but in the present state of the mine no opinion can be given of its prospects.

Dun Mountain Company.

With regard to that block of country which was included in the old Dun Mountain Company's area, and which has lately been taken up and prospected by Mr. Newport, the results obtained are of considerable interest.

During this prospecting certain fresh discoveries have been made, but I consider that, when the old works were being carried on, the deposits of copper which were known to exist did not receive that amount of attention which they deserved, as, in more cases than one, bands of ore have been cut in the drives, and these drives continued, away from the lodes; the lodes themselves, for some reason or other which I am at a loss to account for, never having had any work expended upon them.

Of course many of the old workings have now fallen in, and no information can be gained concerning them; but I shall review in detail those works which I inspected during my trip.

No. 1 *Outcrop, Coad's Point.*—At this point a heavy outcrop of gossan occurs, of considerable porosity and a snuffy-brown colour, with which a little copper is found; and a shallow pit has been sunk on this gossan, resulting in some copper ore-being found, largely mixed however with iron. This outcrop is situated near the north-west boundary of the mineral belt, and is in close proximity to a belt of elvanite. A drive is now being entered at 100 feet below the level of the shaft, with the view of intersecting the ore band at that level; but up to the present time this has not been reached, although two small veins of copper have been met with.

The strike of the lode is north-east to south-west, the underlie being north-west, while on the north-west side of the lode the country is composed of a black granular serpentine.

No. 2 *Outcrop.*—About 20 chains to the eastward of No. 1 outcrop another band of ore has been driven on, but when I visited the locality the drive had fallen in. It however appears to be a parallel vein to No. 1, striking north-east to south-west, and a gossan is also associated with this ore, although not so strongly developed as in the other instance.

No. 3 *Outcrop, Sullivan's.*—At this place copper ore is cropping out on the side of the hill a little above the track, alongside the old chrome workings. Its existence was not known at the time the chrome was being worked, but the outcrop has since been disclosed by a slip. It is from this outcrop that the best samples of ore have been taken by Mr. Newport—the specimens forwarded last year for analysis, which yielded 19·1 per cent. of copper. I did not see any further outcrops of ore until passing round the point of the spur above the manager's house, and from there several outcrops have been found, very little work however having as yet been expended upon them.

No. 4 *Outcrop* is the one from which some black powder containing copper has been obtained, and which has been supposed to be the black oxide of copper; the sample, however, which I analyzed last year contained less than 1 per cent. of metallic copper, but it is probable that this was a very poor sample seeing that some specimens deposit copper on steel very readily.

No. 5 *Outcrop* is the furthest down the mineral belt in the direction of Windtrap Gully before reaching that point, and here a good deal of work has been done. A shaft was sunk on the outcrop of the ore for some distance, and then a drive was put in at a lower level to intersect the lode, which it did after passing through a heavy belt of elvanite. After cutting the lode the drive was continued to a point below the old shaft where an uprise was started, but they did not break through to the shaft. The level was, however, continued for some distance farther on; and, besides this, two branch drives were put in, neither of them striking any ore.

Notwithstanding the amount of work which has been done at this particular point, no attempt appears to have been made to prove the lode which was struck close to the elvanite, as no shaft has been sunk on it, nor has anything else been done to test its quality or extent.

That there is a considerable quantity of copper present in the ore is sufficiently attested by the fact that the water which trickles along the level deposits a thick paste of malachite, a sample of which, analyzed at the Colonial Laboratory last year, yielded 34·8 per cent. of copper.

I must not omit to notice that a rich gossan, similar to that at Coad's Point, occurs associated with the copper lode here, and that in all respects the character of the ore here and at Coad's Point is very similar.

No. 6 Outcrop at Windtrap Gully is obeying much the same rules as those which I have cited above; it is as usual associated with elvanite, and some specimens which I obtained from the lode are very rich, being almost pure copper-glance. The work here consists of two drives, in the upper of which I was able to see the lode, but in the lower one it is timbered up and I could not see it.

The Dun Mountain copper deposits appear to have been most lamentably neglected, doubtless from the impression at the time works were being carried on that the chrome iron deposits would better repay any work expended on them; and when the price of chrome fell the capital of the company was exhausted, and no further works could be carried on. The surface prospects are in most cases superior to any of the deposits at D'Urville Island, and it is much to be regretted that shafts were not sunk on the ore here, and something concerning its extent ascertained. There is no doubt that prospecting this country now will be attended with considerable expense, and, should good ore be found in quantity, a large capital would be required to work it, so that it becomes a matter for grave consideration whether or no money would be well applied on the mineral belt. I certainly think the prospects of the place warrant a certain amount of expense being gone to with a view of tracing the extent of these deposits, which appear to be more regular in their character than is usual in serpentine.

After seeing the serpentine at various points throughout the mineral belt, and noticing the regular way in which both all the beds themselves and also the copper lodes dip to the north-west below the Maitai slate—after seeing this and the general continuity of the different characters of the various zones of the belt, I am compelled to consider the whole belt as metamorphic, and not intrusive. I am aware that this is against the generally-received ideas of the origin of serpentinous deposits, and that I am laying myself open to a considerable amount of criticism in making the statement, but all the points which I can see so strongly advocate this view that I am compelled to take it. Of course if the serpentine is metamorphic there is no reason why lodes should not be as continuous and well marked in it as in any other formation, and the very causes which operated in producing metamorphism also in all probability caused the formation of the lodes.

THE MOUNT ARTHUR REEF.

While in the district I visited the Mount Arthur Reef, the possession of which has recently formed a matter of dispute between two rival parties. The reef, or rather four distinct leaders, is found cropping out in the course of the left-hand branch of Gridiron Creek, which falls into the Takaka River, and is most easily reached from the Graham River. In this direction a track has been made by the late Provincial Government to the Mount Arthur table-land, and after travelling nine miles along this track the reef is reached by about three miles of an unmade bush-track.

It will be as well to note the country which is passed through, although Mr. McKay's map of the country in last year's report shows this. After passing out of the granite which occurs for some little distance up the Graham River, a belt of crystalline limestone is met with, which, however, does not assume such a white appearance as that occurring in the Riwaka Ranges. Mr. McKay has then shown a narrow strip of intrusive rocks which I failed to observe, but, as my trip was a somewhat hurried one, this is not to be wondered at. A considerable thickness of dark-coloured schists (bituminous schists?) and an impure limestone next occur, and these pass up into indigo-blue slates, very similar in character to those I noted last year in the Greenstone River, at Lake Wakatipu.

These schists and slates continue until the head-waters of the Pearce River are passed, and Flora Creek has been followed from its source to the Horse-shoe Creek, at a short distance below which Gridiron Creek is struck, where Cretaceo-Tertiary limestones occur, rising as high cliffs along the banks of the creek and capping the older rocks.

In ascending the Gridiron Creek these are soon passed through, and then the red and green breccias and aphanite slates of the Te Anau series appear, and are of precisely the same character as at their typical locality in Southland, although they do not appear to be of so great an extent at this place as in the Greenstone. It is in a bed of hard grey gritty sandstone that the quartz leaders in question occur, and they are striking nearly north-east and south-west, with an underlie to the south-east; but it is difficult at present to form an exact idea of what the true strike of the reef will be to a degree or two, since the leaders are split up by belts of sandstone, which are of very varying widths, and thus alter the strike of the quartz at different places.

These leaders have been bared for a short distance, and one or two other outcrops of quartz have been found lower down the creek, the course of which the reef appears to be taking. The quartz contains a great deal of iron pyrites, sometimes at least 50 per cent., besides other minerals in smaller quantities, such as galena, pyrrhotine, zinc-blende, and copper pyrites, and when burned gold is generally visible in hand specimens. I forwarded specimens to Wellington for assay which yielded 2 oz. 5 dwt. per ton, and some I saw washed out in Nelson yielded over 2 oz. per ton.

At the present time the existence of a defined reef is not proved; but this can very readily be accomplished by a small shaft, for the leaders exposed at the surface are so near together that they will doubtless join at a very little depth if they are continuous at all. The extent of the reef along its course can also be very readily tested by trenches cut across the strike of the reef down the creek.

Should these leaders open out to a defined reef, carrying gold, the position of the mine is by no means inaccessible, since, although it is 3,500 feet above the level of the sea, a good pack-track already exists to within three miles of the mine, and the formation of this last three miles would be by no means difficult. The occurrence of auriferous reefs in this formation is also of great interest, since, as far as I know, this is the first instance of their having been found connected with the Devonian rocks of the Te Anau series, unless in the Longwood Range, and may possibly open up a great area of country for prospecting with reasonable hopes of success.

Adams's Reef, Mount Ophir Mine.

With regard to Adams's Reef (Mount Ophir Mine), which had just got to work when I visited Collingwood, and from which some very rich specimens were forwarded last year, I have some few remarks to make. The stone which was sent to Wellington was taken from a drive entered in the face of the hill just above the level of Cole's Creek, and at this point the strike of the reef is north-north-east, and the dip south-south-east at an angle of 30 degrees; but a heave which occurs just at the mouth of the drive has altered the apparent course of the reef in the tunnel to east and west, with a southerly dip. It is not, however, at this point that the reef is now being worked, but further up on the hill, where a body of quartz 14 feet thick has been found, lying very flat, but still dipping easterly; and this outcrop, as it is traced towards the drive, gradually thins down to about 2 feet, it being from this pinched part of the reef that the richest gold has been obtained. The stone throughout is very ferruginous, but has a white quartz running through it. It is exceptionally easily worked; indeed, for some months the quartz is likely only to be quarried; and, if any returns to speak of can be obtained, the mine should be successful.

In the same claim a reef of pyrites 4 feet thick has been struck, which strikes east to west, and dips south at an angle of 15 degrees; and the highly ferruginous character of this reef on the surface, together with the existence of a pyritous lode in the Phœnix Claim, renders it probable that this reef also will pass into a vein of pyrites at no great depth.

The reef worked by the Phœnix Company crosses Cole's Creek just above the battery site on which Mr. Adams has erected his machine, and from the south-west outcrop I saw a very good prospect obtained. This reef is about on the line of the Perseverance Reef, and is very possibly a continuation of it, this being rendered more probable by the fact that the carbon slates of Bedstead Gully may be seen here, overlaid by the grey felspathic schists in which the reefs occur.

PERSEVERANCE MINE.

This mine is still closed, but has lately been taken up by Johnston and party as a mineral lease, with the object of working the galena, copper pyrites, and zinc-blende, which are known to occur in the mine. At the time of my visit all the drives had fallen in, and I was therefore unable to examine any of the workings, but I append a few notes which I made concerning the mine.

At the coal-hole above the Perseverance tunnels, but in the same lease, carbon slates appear, underlying certain grey felspathic schists, and these are both greatly contorted at the line of junction. So great is this contortion that the beds which are on either side of the line of junction lying very flat, are here standing nearly vertical, the line of junction itself following an east-south-east direction. This junction-line is of great interest, since, marking it, a belt of quartzose sandstone occurs, in which, at places, small belts of quartz occur, and from this a large quantity of gold was originally obtained. It is very hard to understand how the deposits of gold have been formed in this district, for as a general rule the quartz reefs conform to the bedding of the strata, and even in Adams's Reef, although the foot-wall is very well marked, the hanging-wall is by no means so distinct, and at times the reef is pinched out to a few inches in thickness. Supposing these reefs to be intrusive in character—and we can hardly look upon such bodies of stone as occur as veins of segregation—we can only suppose that they have followed the lines of least resistance.

It is a fact that in New Zealand the reefs as a rule appear to conform to the bedding of the strata, and what would be looked upon as an unfavourable sign elsewhere, can hardly be so regarded in the present instance.

Richmond Hill Mine.

At the date of my visit this mine was closed, and I understand that but little had been done since it was last visited by the department. There was a considerable quantity of ore stacked by the tramway, but this generally appeared to be of an inferior quality to the specimens which have been submitted for examination in the Colonial Laboratory. It is to be hoped that a mine in which such a valuable ore has been found as that raised from the Richmond Hill Mine will not be allowed to stand idle for any length of time.

Before closing my report, I wish to call attention to the numerous pyritous lodes which occur in the Collingwood District, both around Bedstead and Cole's Gullies, and also in the Parapara River, for, when some process is devised for the cheap extraction of gold from pyritous ores, there is no doubt that these will be of great value, all of them carrying a greater or less quantity of the precious metal.

AURIFEROUS REEF IN THE RIMUTAKA RANGES.

REPORT BY S. HERBERT COX, F.C.S., F.G.S., ASSISTANT GEOLOGIST.

Wellington, 8th October, 1879.

I have the honor to inform you that, in accordance with instructions, I have visited the reefs in the Wairarapa District which are at present attracting some attention.

Brandon's Reef, the one from which a ton of quartz was recently sent to the Thames, is situated about sixteen miles from Featherston, along the borders of the Wairarapa Lake, and can be reached with ease. It is cropping out on the banks of a small creek, the name of which does not appear on the map, and about eight years ago attracted some little attention, a drive having at that time been put in for about 60 feet, and a shaft sunk at the end of this drive for a depth of about 20 feet. The reef was, however, abandoned at this time without, so far as I can learn, any satisfactory results having been obtained; and until Messrs. Brandon and party took the matter up, a few months ago, nothing further had been done. The drive has been put in along the strike of the reef, north and south, on the hanging-wall, and from the bottom of the shaft a crosscut has been entered cutting through a leader about 2 feet thick, and then after passing through a narrow belt of slate the main reef is struck; but up to the present this reef has not been driven through, and the thickness is therefore unknown, but it is not less than 6 or 7 feet.

In ascending the creek towards the mine other reefs are met with, one near the mouth of the creek being about 2 feet thick and containing traces of gold. This reef is striking north and south, and conforms to the general bedding of the sandstones in which it occurs; it underlies to the west at an angle of 47 degrees.

Above this sandstone, black slates with numerous quartz leaders are found, the dip being still to the westward, and these slates become more rotten in their higher beds, it being in the rotten black slates that the reef at present being worked occurs.

Several assays have been made of specimens from this reef, and the first one that was submitted to the department yielded gold at the rate of 12 dwt. 1 gr. per ton. This specimen was taken from the leader cut in the cross-drive mentioned above, and when I visited the mine I brought two specimens from the main reef. These specimens yielded on assay 14 dwt. 1 gr. and 12 dwt. 1 gr. of gold per ton respectively, a return which is very encouraging in view of the large body of stone and the facilities which exist for working the mine.

A further test has been applied to the stone in crushing 21 cwt. of it at the Thames, a yield of 1 oz. 3 dwt. having been obtained according to the prospectors; but I do not consider that up to the present a sufficient test has been made to prove the mine a success. There is, however, sufficient inducement in the results obtained so far to make it worth while to try the stone on a larger scale, and this, I believe, is contemplated by Messrs. Brandon and party.

There are several other reefs in the district running parallel to the main one, and these in some cases have been found to contain a little gold, from 4 dwt. to 8 dwt. being about the usual amount.

The slates in which Brandon's Reef occurs are the same as those occurring near the summit on the Rimutaka line, and I think it would be advisable to withdraw the land from sale east of a north and south line drawn from the summit, as this would probably enclose all the auriferous country so far as at present known.

I may mention that the course of the reefs is well marked, and that they can be traced for miles from the old Pioneer Claim, near Palliser Bay, in a northerly direction through Brandon's reef (the old Galatea), and from there on through the flanking ranges of the Wairarapa Lake; and throughout the whole distance they are in easily accessible positions, and are surrounded by quantities of timber suitable for mining purposes. There is sufficient water in the creek on which Brandon's Reef is situated to work a turbine during the winter months, but I believe the creek is nearly dry in the summer, so it will probably be necessary to work any machinery by steam.

GEOLOGY OF THE RODNEY AND MARSDEN COUNTIES.

REPORT BY S. HERBERT COX, F.C.S., F.G.S., ASSISTANT GEOLOGIST.

INSTRUCTIONS BY DR. HECTOR.

AFTER completing your work in the Nelson District, you will proceed to Auckland and examine the beds from Auckland Harbour north into the Kaipara District, paying special attention to any changes which take place there. Note carefully whether Jurassic or older rocks occur in the district, and collect fossils throughout if they occur. You will also examine the beds at the Manukau North Head, and collect rock specimens.

In this trip you will be accompanied by Mr. Park, as collector, and you will use your discretion as to what time you can best devote to your work as Inspector of Mines, leaving Mr. Park to do detailed work and make collections while you are so engaged. If you find that you have time, and are able to do so, I wish you also to examine the southern Waikato country from Cambridge, as I found last year an extension of the coal-beds in this direction towards Rangitoto Mountain, which is a slate formation.

1st August, 1879.

NARRATIVE.

I HAVE the honor to inform you that, in accordance with your instructions, I left Nelson on Saturday, 8th November, arriving in Auckland on Tuesday, 11th November, from which date until Saturday, the 15th, I was employed on the district around Auckland, the weather preventing me getting further to field. On Monday, the 17th, I started for the Manukau Heads, and spent the time until Saturday, 22nd November, in the Waitakerei Ranges. On Sunday, the 23rd, I was joined by Mr. Park, and until Saturday, 29th November, we were engaged on the country between Manukau Heads and Riverhead. The following week was devoted to the country between Riverhead and Helensville, as well as a part of the country between Riverhead and the North Shore; and, Mr. Park having left overland for Mahurangi from Helensville, I devoted the early part of the next week—8th December—to the inspection of the Waikato mines, leaving for Mahurangi by the steamer on Friday, 12th December, from which date until Christmas we devoted our attention to the structure of the country from Mahurangi to Mangawhai, and across to Wellsford and Kaiwaka. From the commencement of the new year until the 22nd January we were engaged on the Kaipara Harbour between Port Albert and the Northern Wairoa, as far as Tangiteroria, taking in Tokatoka, Pahi, the Otamatea, and Maungatoroto; and on the 23rd January I left for Whangarei with Mr. McLaren to inspect the mines there, Mr. Park having ridden overland to join me, and until the 5th February I was engaged on this work at Whangarei and the Bay of Islands. From the 5th February to the 15th February we spent in examining the beds from Whangarei south to Mangawhai and west to Tangiteroria; and, returning to Auckland on the 16th, I left for Waiwera the next day, where I remained for two days, leaving for Wellington on the 24th February, and arriving there on the 27th February.

REPORT.

The various formations which have been studied during this trip may be subdivided as follows, no alteration in the general scheme being made from the classification of 1879. It will be seen, however, that this year's work has shown that some of the conclusions which had been arrived at as regards the age of certain beds were wrong; and these are now rectified:—

Classification.

I. Recent and Pleistocene	1.	Blown sands.
	2.	River silts.
	3.	Consolidated sands with lignite.
II. Pliocene ..	4.	Scoria streams and craters.
IV. Lower Miocene..	5.	Trachydolerite breccias.
	6.	Trachyte sands and concretionary greensands.
	7.	Sandy marls (plants and fossils). Grits and slate-breccia (fossils).
V. Upper Eocene ..	8.	Limestone and grit.
VI. Cretaceo-Tertiary	9.	Chalk-marls and flints. Limestone (hydraulic). Firestone.
	10.	Calcareous greensands (glauconitic). Limestone in flakes and cornstones. Dark greensand and red sandstone. Coal.
VII. Lower Greensand	11.	Quartz sandstone (micaceous) with *Inoceramus*.
XIIB. Upper Devonian	12.	Slates and aphanite.
	13.	Dykes, bosses, and trachytic flöes of uncertain age.

I.—RECENT AND PLEISTOCENE.

1. *Blown sands.*
2. *River silts.*
3. *Consolidated sands with lignite.*

Little need be said of the blown sands. They occur along the sea-coast from Muriwai north as far as I went beyond Dargaville. They rise to considerable altitudes, two or three hundred feet in the coast ranges, and give a most curious appearance to the summits of the hills which are largely covered by them; they appear to be bounded by the summits of this coast range generally, as in only a very few cases do they descend to the eastern side of it. On the East Coast minor sand-dunes occur, the most important of these being between Mangawhai and Pakiri, where a stretch of country twelve miles long and three or four miles broad is completely composed of them.

The river silts occupy some considerable area towards the mouths of the slow-flowing rivers which deliver themselves into the Kaipara Harbour, and occur again at Waipu, Mangawhai, Pakiri, &c., They generally consist of fine-grained sandy silts, and have no particular points of interest connected with them, except that near Helensville they form the only land which offers any inducements for cultivation.

The consolidated sands are beds of more or less horizontally stratified quartzose sands, with which are associated shaly beds, and heavy deposits of lignite along the seaward coast of the Kaipara North Head, extending far north towards the Mongonui Bluff. They have an important development in this part of the country, being the only consolidated beds which occur between Dargaville and Helensville on the western side of the Kaipara Harbour. They also occur as patches on the western side of the harbour, flank well up on to the limestone north of Dargaville, and are again seen at the south head of the Whangarei Harbour, where they cover a considerable stretch of country in the direction of Waipu, as may be seen on the accompanying map.

II.—Pliocene.

4. *Scoria streams and craters.*

These beds are best represented in the neighbourhood of Auckland, but also occur up the Wairoa River at Mount Tauhoa and Mount Maungatipu, and around Whangarei occupy a considerable area of country. They consist of a number of extinct volcanoes, the craters of which are more or less perfectly preserved; in some cases, as at Mount Eden, Mount Rangitoto, Maungatapere, Tauhoa, &c., these being in as good order of preservation as they were when the last eruption ceased. Round Auckland there are various streams of basaltic lava which are quarried for building purposes; but the most noticeable feature of the district is the scoria with which everything is smothered, and which forms the whole of Rangitoto Island. Rangitoto then is essentially a tuff crater, and, besides this, a number of small tuff craters occur scattered over the Auckland Peninsula. Volcanic bombs are of frequent occurrence, and of all sizes, exhibiting the pear-shaped forms and spiral ends characteristic of their mode of formation.

Besides these, numerous included pieces of marl, &c., are found which have been completely altered by the heat to which they have been submitted, and are now found as porcellanites.

In the northern district where these rocks occur they are far less frequently found in this scoriaceous form, but occur as basaltic lava flöes, and form, at times, plateaux of considerable extent—as at Whangarei and in the surrounding country—the ashes or scoria being generally represented by tufas which are found associated with the solid basaltic rocks. It would appear that the eruption or series of eruptions here must have been far more violent than those round Auckland, as is evidenced by the greater height of the volcanic cones, such as Maungatapere, Mauno, Hikurangi, Kaurihorehore, &c., and by the much greater extent of the solid lava flöes. In this northern part, again, mineral water springs are of frequent occurrence, and they vary considerably in their character, at times being chalybeate and at others saline, these last being locally known as sodawater springs. These springs also occur in the slates of the district, as I shall have occasion to mention by-and-by.

Round Tauhoa less is known of these beds, as the impenetrable nature of the bush there, and the absence of tracks and roads, render the examination of that district a matter of some difficulty.

IV.—LOWER MIOCENE.

5. *Trachydolerite breccias.*
6. *Trachyte sands and concretionary greensands.*
7. { *Sandy marls (plants and fossils).*
   { *Grits and slate-breccia (fossils).*

The highest beds of this series are the trachydolerite breccias, which occur at the Manukau Heads. They consist of heavy angular volcanic breccias, which are regularly stratified, resting quite conformably on certain glauconitic sandstones, which pass down into the Waitemata marls, as developed in the Manukau Harbour. They are certainly not less than 700 feet in thickness here, and are traversed by several dykes. The section at the Manukau Heads is about the only one in which a good sequence of strata can be seen, from the breccias down; but as these breccia beds are followed further north, through Waimauku, the character of the Waitemata series appears to change, and, from being composed of marls, with occasional beds of soft sandstone and grit, we find them becoming far more sandy. They are still mixed up with a good deal of volcanic ash, and at times really merit the name of trachyte sands which has been applied to them. Breccia beds appear in close connection with these up the Kaipara Harbour, and then beds of heavy concretionary greensands come in, which are quite distinct in character from the typical beds of the Waitemata series, but which are not the less their equivalents, or, rather, they represent the lower part of the breccias and the upper part of the marls. They are largely developed in the northern part of the district, certainly overlying the more marly portions, such as those which occur around Auckland, and also along the coast from Waiwera to Cape Rodney; and, in the neighbourhood of Cape Rodney, the base of the series is represented by a coarse slate breccia-grit with numerous fossils. The grit is overlaid by black marls, which pass into greensand marls, and from those into concretionary greensandstone. Over on the Kaipara side again, at Komiti Point, fossiliferous beds (gritty) occur at the base of the series, the greensandstone capping them at a short distance off, and these beds, curiously enough, contain, associated with a great preponderance of Lower Miocene forms, the *Pecten pleuronectes* and *Pecten fischeri* of Orakei Bay, on the occurrence of which we have ascribed a Cretaceo-Tertiary age to these beds. It appears now that we must have been making a mistake in so doing, since a direct sequence can be traced from the breccias of the Manukau Heads down to the Waitemata beds, as they occur round Auckland, and these breccia beds also occur associated with the greensandstone, so that the gritty beds of Komiti Point and Cape Rodney must really be the equivalents of some part of the Waitemata marls. This is further born out by the occurrence of pebbles of volcanic rock being constantly associated with the upper part of the Waitemata beds around Auckland and on the North Shore, and the occurrence of the Orakei Bay fossils in the beds of Komiti Point adds further confirmation to the fact. It is not without taking considerable trouble to settle these relations that I make this assertion, since it affects our classification somewhat, and may do so even more when further detailed work is undertaken; and the reason for this is that we have always considered *Pecten pleuronectes* to be a typical fossil in the Cretaceo-Tertiary series—indeed, to be almost confined to the Leda marls; and now to find it associated with a large number of Pareora fossils is apt to throw discredit on those fossils which we have considered as distinctive of any special horizon.

V.—Upper Eocene.

8. *Limestone and grit.*

These beds appear to be the true equivalents of the Mount Brown limestone. They occur at Captain Colbeck's, above Pahi, on the Pahi River, where they strike north 40 degrees west, and are standing nearly vertical, being overlaid unconformably by the greensand marls of the last-mentioned series. They form a remarkable gorge in the Pahi River, known as the Gibraltar Rock, and occupy a block of country about two miles square, as shown on the map. They are again met with on the Whangarei side, the Whangarei and Waipu caves occurring in them; and they are also found at Kamo, Ruatangata, Hikurangi, and further north again at Kawakawa, in each instance overlying the coal formation or Cretaceo-Tertiary series unconformably. They contain a number of fossils, but these are very difficult of extraction, owing to the compact nature of the stone, which is sufficient to class it amongst the ornamental stones as marble, although it has not the saccharine structure of those classes which are useful for statuary purposes. It is more or less glauconitic in places. In no case were beds seen resting conformably on this limestone, so that a break occurs both above and below it in this northern district.

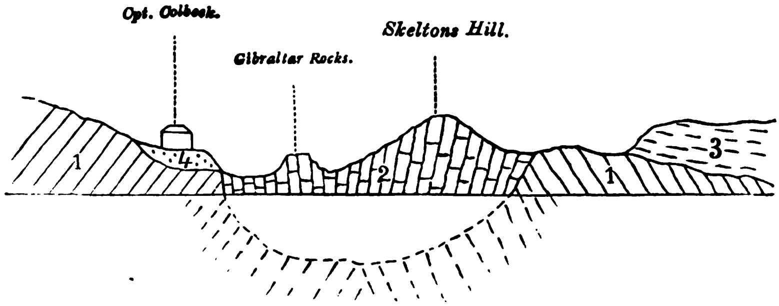
VI.—CRETACEO-TERTIARY.

9. { *Chalk-marls with flint.* / *Limestone (hydraulic).* / *Firestone.* }

10. { *Calcareous greensand (glauconitic).* / *Limestone in flakes and cornstones.* / *Dark greensand and red sandstones.* / *Coal.* }

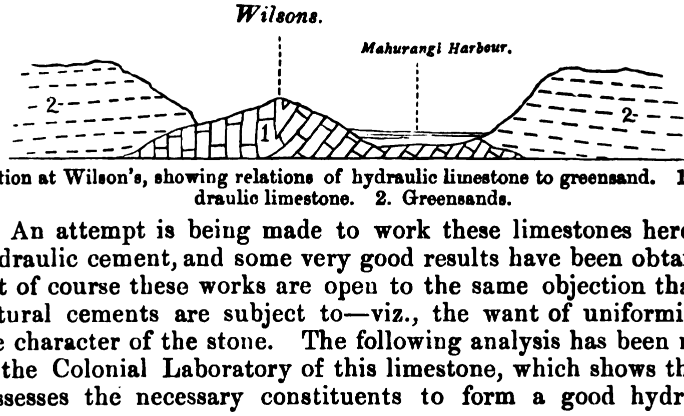
The beds included under No. 9, although quite distinct in their character, are nevertheless somewhat difficult to break up in the district examined; but, when I say that between Port Albert and Tauhoa is the most notable place in which the chalk-marls with flints occur, that at Mahurangi the hydraulic lime is being burned and sold for cement, and that at the Matakana South Head a deposit of the firestone, a highly siliceous rock, occurs, I have sufficiently alluded to their modes of occurrence to enable me to describe the beds themselves and their relations to other beds.

The chalk-marls with flints, which in the Port Albert District appear to be the highest beds of the series, are well seen on the track between that place and the Kaipara Harbour at Tauhoa. They form hills which, while they carry a better class of soil than the clay-marls of the Lower Miocene series, do not approach the limestone soil which adjoins it towards Wellsford. These beds are noted for the number and beauty of the flints which are included in them; they are generally standing at high angles, and have a strike which approximates to north and south. They rest, as before stated, upon hydraulic limestone, which covers a considerable area in the Kaipara District, occurring as a general rule in comparatively low-lying grounds, the surrounding highlands being composed of the concretionary greensands of Lower Miocene age, which rest unconformably upon them. Near Captain Colbeck's they abut against the Eocene limestone, both standing at high angles, but their strike differing more than 40 degrees, thus proving their complete unconformity.



Section from Captain Colbeck's north, showing relations of hydraulic and Whangarei limestones. 1. Hydraulic limestone. 2. Whangarei limestone. 3. Miocene greensands. 4. River silts.

At Mahurangi they occur under similar conditions, cropping out in low grounds about the banks of the river, and in the Kaipara flats, being overlaid unconformably by the concretionary greensands.



Section at Wilson's, showing relations of hydraulic limestone to greensand. 1. Hydraulic limestone. 2. Greensands.

An attempt is being made to work these limestones here for hydraulic cement, and some very good results have been obtained, but of course these works are open to the same objection that all natural cements are subject to—viz., the want of uniformity in the character of the stone. The following analysis has been made in the Colonial Laboratory of this limestone, which shows that it possesses the necessary constituents to form a good hydraulic cement:—

Analysis.

Carbonate of lime	64·5
Carbonate of magnesia	5·1
Iron oxide with alumina	6·8
Soluble silica	13·2
Clayey matter	10·4
Alkaline salts	Traces
	100·0

The firestone is a very fine-grained siliceous rock, containing 90·79 per cent. of silica. It is known locally as fireclay, and is well developed at the Matakana South Head, where it is standing at high angles, having no apparent association with the limestones there, but being overlaid unconformably by the greensands, &c.,

in the same manner that the limestone is capped by them elsewhere. It is a very interesting rock, and has the following composition :—

Analysis.

Silica	90·79
Alumina	2·29
Iron oxides	·89
Lime	2·41
Magnesia	·44
Water	3·18
Alkalies	Traces
	100·00

A somewhat similar rock occurs at Kawakawa, where it is found overlying the coal. It has the following composition :—

Analysis.

Silica	93·35
Alumina, with Iron oxides and Manganese	2·54 Trace Trace
Lime	1·59
Magnesia	·20
Alkalies	1·52
Water of constitution	·80
	100·00

Deposits of bog iron ore are of frequent occurrence associated with these beds, and indeed small lapilli of ironstone are scattered over the surface in almost every locality at which they occur, and could, I think, with advantage, be employed in many places to fix the boundaries of the beds where other and more reliable data are wanting. About a mile from Port Albert, in one of the arms of the harbour, over which a bridge crosses, there is an outcrop of limestone with greensands interbedded, the limestone possessing that curious cone-in-cone structure which is so characteristic of the Awanui beds of Poverty Bay. These beds, as far as I could make out, are associated with the hydraulic limestones and firestones which certainly occur across the bridge, and, although they may possibly lie unconformably below these, there is no satisfactory evidence to be gained at this place, for the beds are so much bent and twisted as not to give reliable bearings for strike and dip. That somewhat similar beds occur at Mahurangi, and are there unconformably below the hydraulic limestones, will be mentioned by-and-by.

If these cone-in-cone beds are interstratified with the chalk-marls and hydraulic limestones, as they appear to be, it would give a certain amount of evidence in favour of the whole series being older than I have considered it in my report, since the Awanui beds of Poverty Bay contain *Inoceramus*, and are considered to be of Jurassic age; they have also chalk-marls associated with them there in much the same way as at Port Albert. As, however, we are simply dependent upon physical characters for the determination of the age of these beds, I think it will probably be better to assign to them the position given in the table, firstly because at Kawakawa the characters of the beds which overlie the coal closely approximate to those of the clay-marls which have been already described; and a further proof is obtained at Pahi Point, where greensand beds occur below the limestone from which Dr. Hector obtained several fossils which characterize the roof of the Whangarei coal, *Cardium brunneri* being amongst the number.

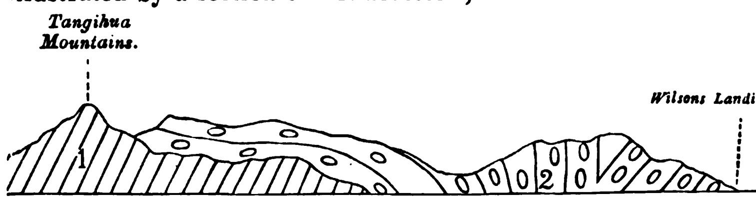
The beds No. 10 are more distinctive in their characters, and are, generally speaking, more highly fossiliferous; those last described being utterly devoid of fossils throughout their entire area as far as yet known. The two first beds, "calcareous greensands" and "limestones in flakes and cornstones," are better seen on Limestone Island, Whangarei, than at any other locality with which I am acquainted. At the northern end of the island, the beds, which are here dipping north-east at varying angles, averaging about 30 degrees, consist of marly limestone, much laminated; and these appear to represent some part of beds No. 9, although not entirely corresponding with any of them in character. As we pass southward a bed of greensand, which is crowded with fucoid stems, appears; this in turn passing down into a flaggy limestone which forms the southern end of the island. It is this limestone which is described in the table as occurring in flakes and cornstones, and it is possible that some parts of the areas mapped as the hydraulic limestones, especially around Pahi, may in reality be these beds, but the absence of fossils makes it impossible, without very close detailed work, to discriminate between them in far-distant localities.

On Rabbit Island, between Limestone Island and the Mangapai Channel, sandstones occur dipping below these beds again, and these are in all probability the same as those sandstones which are so highly fossiliferous on Tiger Hill, and which are the local representatives of the roof of the coal. These beds are the "dark greensands and red sandstones" of the table, and they occur as the roof of the coal at the Whauwhau Mine, and at various places north and south from Waipu to Hikurangi, forming Mount Tiger and capping the Whareora coal; but this represents a very considerable thickness of strata, and it is quite possible that the subdivisions which I made in my report on the Whangarei District in April, 1877 (Geological Report, 1876–1877), may hold good. In that report I considered that the limestone of Limestone Island replaced the coal and was directly below all these greensand beds, and even now I have no direct evidence to prove that I was wrong in forming these conclusions, more especially in the face of the section below Manaia (see previous report), where the limestones are distinctly dipping below the greensands: but in view of the evidence gained elsewhere, as at Kawakawa and Pahi, it appears quite possible that the greensands at Manaia may in reality be the interbedded fucoidal greensands which occur at Limestone Island, and, with regard to those greensands which form Grahamstown Point, they very probably belong to the Lower Miocene beds described further south, with which I was unacquainted at the time of my previous report. I have, however, no proof that such is the case, and, failing this, have preferred to leave the boundaries on the map the same as before, but shall be quite prepared for subsequent work proving that they in reality belong to the younger series, and that the greensands, &c., passed through in Messrs. Dent and Beddington's boreholes are of the same age. Mr. Love, one of the proprietors of the Whauwhau Mine, is proposing to bore at Grahamstown for coal, and should he be successful in his work it will place the matter beyond doubt and will serve as a guide in future work. The coals I shall mention separately in the summary of this report: they all occur about the base of the series, in the northern part of the Auckland Province, but under somewhat varying conditions, which will not be uninteresting to note.

VII.—LOWER GREENSAND.

11. *Quartz sandstone (micaceous) with Inoceramus.*

These beds are better seen on the Wairoa River, at Wilson's Landing, below Tangiteroria, than anywhere else that I am acquainted with. They consist of micaceous quartzose sandstones and shales, striking north 20 degrees east and dipping eastward at an angle of 70 degrees, and on the opposite side of the river they are found to contain *Inoceramus* and a small *Pleurotomaria (?)*; but fossils are by no means plentiful. At the base of the Tangihua Mountains the same beds are found lying almost horizontal, as illustrated by a section of Dr. Hector's,—



Section—Tangihua to Wilson's Landing, on Wairoa River. 1. Slates. 2. Micaceous sandstone with *Inoceramus*.

and they in all probability extend along the western flanks of the slate ridge as far as Mangawhai, the beds which flank the slates on the dividing range between Maugawhai and Waipu having much the same characters as these beds, but not yielding any fossils.

Another outcrop of these beds as heavy concretionary greensands occurs at Mahurangi, where they are striking east and west, with a dip south of 70 degrees. At this place they weather brown, and are interstratified with shales as thin partings, with films of coal. It is possible that the greensands and cone-in-cone limestones of Port Albert may belong to these beds; but as I was unable to prove this with any degree of certainty, indeed, as they appeared to be more nearly allied to the hydraulic limestones, I have grouped them with these beds on the map, and should any distinction be made the area occupied by them is but small.

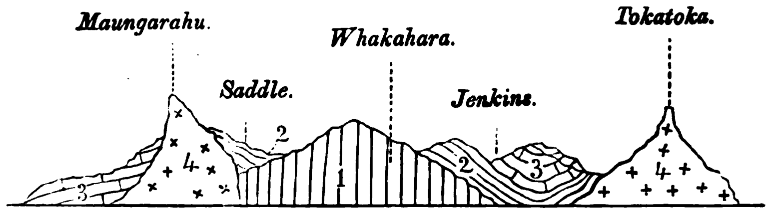
XIIb.—Upper Devonian.

12. *Slates and aphanite.*

These beds are composed of clay-slates, with which are associated numerous patches of carbonaceous matter and pyrites at places. They are all more or less tufaceous in character, and in all probability belong to the Upper Devonian series, as is further demonstrated by the occurrence of the red and green breccias of the Te Anau series, associated with them in the Waipu Gorge. They are the same slates as those which occur at Whangarei and north to the Bay of Islands, carrying deposits of manganese oxide at places, as at the Bay of Islands, Whangarei, and Waipu, at the back of Morrison's; and they are found again forming the basement rock at Cape Rodney, Little Omaha, and Matakana Heads, cropping up again in Kawau and Great Barrier Islands, and in all probability being of the same age as the slates at the Thames. They are, however, nearly devoid of quartz in this northern district as far as could be seen, but of course future explorations may discover quartz or metalliferous veins associated with them. The general strike of these beds is north and south, and they are standing at very high angles. Certain mineral-water springs have been struck issuing from these rocks in driving a tunnel through them at Whangarei for the purpose of opening up a deposit of coal which exists on the other side of the slate ridge.

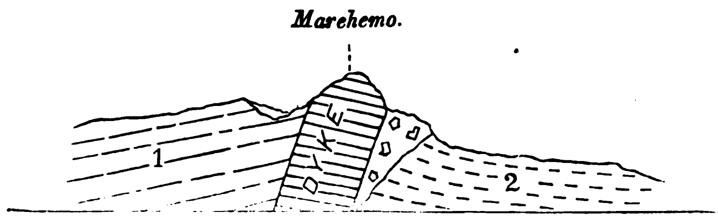
13. *Dykes, bosses, and trachyte flöes of uncertain age.*

Some very interesting dykes and bosses of igneous rocks occur in different parts of the country examined. Of these, the most curious is a rock which is found cropping out at the back of Wilson's, between Wellsford and Port Albert, which appears to be composed of an intimate mixture of augite and quartz. It is occurring as a boss which rises through the hydraulic limestones there, but at no great distance from the junction of the limestones and Lower Miocene greensands. Another instance is at Tokatoka, where a large dyke of a trachytic rock occurs, in which are a large number of crystals of aragonite, and these are again represented at Maungarahu. At both of these places the hard dyke rocks rise as high peaks, towering above the surrounding country. Between these two points a belt of slate occurs, at the back of Whakahara, the hydraulic limestones flanking them with firestone, and the greensand marls (Lower Miocene) rest upon them to the eastward.



Section—Tokatoka to Maungarahu. 1. Slates. 2. Shales. 3. Hydraulic limestone. 4. Trachytes and porphyry.

Another small dyke occurs at Matakohe; and at Marehemo, a high hill on the eastern side of the Otamatea arm of the Kaipara Harbour, Dr. Hector has noted (MS.) the occurrence of another dyke.



Section through summit of Marehemo. 1. Chalk-marls. 2. Greensands.

A similar formation is met with at Pukekorero, where the greensands rest on the plutonic rocks, and dykes of a similar character appear at the base of Manaia at the Whangarei Heads, and also at Awaroa, where a trachyte dyke occurs, striking north 45 degrees west in the direction of Grahamstown, at the back of Mount Parahaki. In the latter cases these dykes are overlaid by or possibly intruded through volcanic breccias at the Whangarei Heads, and a certain curious tufaceous and pumiceous deposit which forms Mount Parahaki in the other locality.

There is, therefore, some doubt whether these dyke rocks are of greater age than the Cretaceo-Tertiary series, which would then have been deposited around them in the same way that beds would now be deposited around the Sugar-Loaves at Taranaki, or whether they are intrusive dykes of later date, in fact contemporaneous with, or younger than, the volcanic breccias of the Manukau Heads and Manaia, in which case they have been forced through these beds during Miocene times.

There is not a great deal of evidence which can be adduced in this case, but the occurrence of dykes traversing the breccias themselves at the Manukau Heads clearly shows that volcanic activity was going on subsequent to their deposition, and it would be quite rational to suppose that some at least if not all of the dykes enumerated above were contemporaneous with these. However, I must leave this an open question for the present, until a more thorough comparison has been made between the dyke rocks of the colony, when their characters will in all probability offer some clue by which to classify them, and their age may by that means be determined.

Having now described the general character of the beds and the subdivisions which have been considered necessary, we will pass on to a more detailed description of points of interest met with in the course of the work, and this will be best accomplished by mentioning the various formations which are met with in travelling over the country.

In carrying out our work we made Auckland our head-quarters, and worked northwards, examining first of all those beds which are found in the vicinity of the town and from there to the Manukau Heads; and although our investigations were confined chiefly to the Waitemata series, as regards their relations, the work was by no means devoid of interest.

Auckland to Manukau Heads.

The beds of the Waitemata series consist of alternations of a soft brown sandstone and marl. These beds present very varied characters even round Auckland, and when they are traced further north they undergo a complete change in their characters, as pointed out before (page 16).

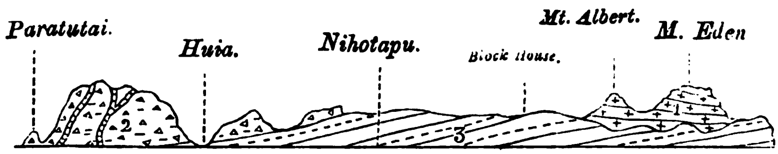
The lowest beds of the series around Auckland are greasy marls, and these pass up into beds of more sandy marl and soft sandstone, in which fossils are very rare with the exception of minute forms; but in one or two thin beds, as for instance at the well-known locality of Orakei Bay, fossils are more plentiful, *Pecten pleuronectes* and *P. fischeri* occurring in considerable numbers, as well as nummulites, and a short tube which has the general form of the phragmacone of a belemnite, but exhibits none of the structure peculiar to that form.

Above these beds the Parnell grit comes in, interstratified with sandstone and thin beds of sandy marl, which occur throughout the series; and this grit, together with a certain quantity of volcanic ash and occasional angular stones, represents the commencement of the volcanic outburst, which, while some of the ash and smaller stones were spread far and wide over the sea-bottom on which the Waitemata series was deposited, attained its greatest development near the Manukau Heads, where beds of breccia at least 700 feet, and probably considerably more, in thickness may be seen resting in direct sequence on the marls, &c., of the Waitemata series, the higher beds of this series being notable for the great abundance of volcanic material which is mixed with the sand

and clay. It seems probable that the volcanic activity which must have prevailed during the latter part of the deposition of the Waitemata beds, and the consequent rapid accumulation of material which must have been taking place on the sea-bottom, may account for the great absence of animal life during the latter part of this period.

These breccia beds which I have mentioned occur at the Manukau Heads, and along the coast are traversed by numerous dykes of a basaltic character which strike generally north and south, dipping west, and are thus running directly at right angles to the bedding of the rocks themselves; but in one or two instances, notably at Karekare, these dykes appear to conform more to the bedding of the rocks. They are very clear and well defined, and can often be seen for a vertical height of about 700 feet, the sides being quite distinct.

The following sketch-section from the Manukau Heads to Auckland will illustrate the foregoing relations :—



Section—Manukau Heads and Waitemata Harbour. 1. Basaltic lavas. 2. Trachydolerite breccia. 3. Waitemata marls and sandstones.

The grit and fine-grained breccia beds are again seen on the North Shore, at Auckland, interstratified with the marls, &c.

The isthmus on which the town of Auckland is situated is dotted by a number of small extinct volcanoes, the whole of the country being smothered in a basic scoria which has been ejected from their craters. Prominent amongst these, Mount Eden and Mount Albert stand out, and also the Island of Rangitoto, which is an exceedingly well-preserved crater, with scoria extending down to the water's edge on all sides. These scoria-beds around Auckland are resting on an irregular surface of the Waitemata marls, and, from their porous nature, allow the water to percolate through them freely until reaching the marls on which they rest, and, these being almost impervious to water, springs are of frequent occurrence throughout the volcanic area. The town of Auckland derives its water-supply from these springs.

The basic volcanic beds stretch from Auckland nearly to the Whau, where the Waitemata series appears from below them, forming the narrow neck of land between the two harbours, the dip at the Whau being east-north-east, at an angle of 20 degrees. This dip appears to hold towards the Waitemata Harbour, but crossing a small bay in the Manukau Harbour a fault is met with, near which the beds are much contorted, and after passing away for some little distance on the southern side of it they take on a dip of south-east at an angle of 35 degrees. The beds here consist of soft sandstones and marls with occasional hard bands and concretions, at times somewhat ferruginous, and beds of a fine-grained black grit also occur; I noticed one bed about 20 feet thick containing considerable quantities of small pieces of pumice. At Puponga Point the marls are dipping south-west 30 degrees, and at Paratutai sandstones occur dipping north 15 degrees east, at an angle of 25 degrees.

Auckland to Riverhead.

Passing northwards up the Waitemata Harbour in the direction of Riverhead the Waitemata beds are highly contorted, anticline and syncline following one another in rapid succession, the area of greatest contortion appearing to be about the position of Lucas's Creek, and in a belt of country extending from Onehunga across the Waitemata Harbour at the above locality, and thence to the Wade, it is the exception to find a bed with a moderately-flat dip, and by no means unusual to find overturned strata, the section at the Whangaparaoa Bluff being a remarkable instance of this.

When Riverhead is reached the beds are lying much flatter again, and here we obtained several specimens of volcanic rocks from boulders which appear to be included in the sandy marls in much the same way as the volcanic ashes and small pieces of scoria are included in equivalent beds on the North Shore.

Manukau Heads to Helensville.

The volcanic breccias of the Manukau Heads may be traced northwards continuously through the Waitakerei Ranges and along the coast until reaching Muriwai, where they are overlaid by blown sands, and from this point they pass more inland, crossing the railway line between Waimauku and Rewiti, and stretching in the direction of Kaukapakapa. I have mentioned before that these breccias are traversed by large basaltic dykes in which the columnar structure of basalt is very striking, and, curiously enough, near the junction of these dykes with the surrounding country small quantities of metallic copper occur, finely disseminated throughout the rock. I have not seen sufficient indications of the presence of copper in payable quantities to hold out any inducements for prospecting; but, at the same time, the existence of metallic copper, even in minute quantities, at several different localities, is at least worthy of note.

I may mention that a little gold is also reported to occur in connection with these rocks, and that even a "gold mine" was started some years ago in the Waitakerei Block, on a bed of chert which is striking north and south through the country, but which evidently contained little or no gold, since it was abandoned very soon, Down the Kaipara River to Helensville there are some flats of moderate extent which have been formed by the river as it has altered its course from time to time, and these flats have been cultivated to a certain extent, but large raupo swamps yet cover considerable areas. A hot spring is issuing through these beds, at the position shown on the map. Close to Helensville there are beds of fine sandy silt, considerably above the present water-level, and these can be well seen beyond the station in a cutting for the railway. The silts of the Kaipara River compose the whole of the low grounds until the spit which forms the Kaipara South Head is reached, from which point, indeed, from Muriwai to the South Kaipara Head, the blown sands cover the whole country to seaward, while a strip of land along the edge of the harbour is composed of the consolidated sands. I have not examined these beds, and so can offer no special description of them in this locality.

Helensville to Mahurangi.

Passing across the country from Helensville towards Mahurangi, the Waitemata series, which is more sandy here than in the Manukau Harbour and the vicinity of Auckland, extends along the road for about a mile and a half beyond the Kaukapakapa Hotel. At this point the volcanic rocks begin to occur as scattered boulders, and further on, at the head of Omeru Creek, the volcanic breccias of the Manukau Heads are found *in situ*, appearing as outliers on the marls. Following the road, the breccias occupy all the country as far as the Makarau Bridge, where the Waitemata marls again crop up, and a very clear section, with the breccias conformably overlying them, is seen in the road cuttings beyond the bridge. This outcrop of the marls appears to be of little extent, as heavy concretionary greensands are picked up before Palmer's saw-mill is reached; and here I must again call attention to the fact that the Waitemata series become far more sandy in character as the distance from Auckland is increased, a bed of greensand occurring at the Manukau Heads below the breccias, and greensands again occurring here. Owing to the dense bush and rough nature of the ground, no connection between the Waitemata series and the greensands could be made out in this locality. From the Makarau Bridge the volcanic breccias stretch in a line to a point about a mile beyond the Areparera Bridge, the greensands occupying all the country on the east and north of them, and the south and south-east boundaries of the breccias may be approximately marked by a line drawn from the Makarau Bridge to the sources of the north-west tributaries of Kaukapakapa River, and thence to the head of the Omeru Creek, which forms the western boundary as far as the Makarau River; farther north it is bounded by the silts of the Makarau and Areparera Rivers. Along the road from a mile beyond the Areparera Bridge to Mahurangi nothing but the greensands and greensand

marls are to be met with, except in the Kaipara Flats near Mahurangi, which consist of the hydraulic limestone.

District around Mahurangi.

Mahurangi and the immediately surrounding neighbourhood offer a considerable amount of information concerning the relations of the different beds, and the structure of the country, as within a very small area certain concretionary greensands, which belong either to the Lower Greensand period or the Jurassic, as equivalents of the Mataura series; hydraulic limestones, which are classed amongst the Cretaceo-Tertiary series; and the concretionary greensands and greensand marls of Lower Miocene age, occur.

The lower concretionary greensands occur at the Mahurangi Bridge, where they occupy but a small surface-area of country, and are striking east and west, with a dip to the southward of 70 degrees. They are unfossiliferous so far as I know, and their general characters have been previously described (page 22). In the gully under Mr. Palmer's house, clay-marls, passing into limestone shales and subcrystalline limestone with greensands, occur, striking north 20 degrees east, and dipping south 70 degrees west at an angle of 25 degrees. This sudden change of strike and dip in a distance of only a few chains is quite sufficient to demonstrate an unconformity between the beds, these younger ones being allied to the hydraulic limestones, although differing in character somewhat from them. Further down the river, outcrops of the hydraulic limestone are met with, occupying the low grounds, and generally striking north and south, and standing at very high angles. At Wilson's lime-kiln, about one mile below Mahurangi, they form a sharp syncline, and occur as a reef across the harbour, the banks of which are composed of the concretionary and marly greensands, which rest unconformably on their upturned edges, as illustrated by the section (page 19). In a white cliff outside the Matakana South Head, an outcrop of the firestone, which is a a siliceous mudstone, occurs under similar conditions to the above: it is standing at high angles, and is overlaid unconformably by the greensand marls, which are lying horizontal or nearly so, and more nearly approximate to the Waitemata series in character than those which we have lately been considering, and towards the base these pass into breccia, which will receive further attention as we pass northwards. Dr. Hector mentions (MS.) that outside the Mahurangi North Head a breccia conglomerate occurs, containing fragments of slate, quartz, and white granular limestone, which gives additional proof, if it were needed, of the unconformity of these beds to the hydraulic limestone. Several small outcrops of the hydraulic limestones occur in this district, but always occupying the low ground, and being surrounded by the Miocene beds, which are always more or less horizontal, and in the Kaipara Flats they occupy a considerable area.

Mahurangi to Waiwera.

Between Mahurangi and Waiwera no change takes place in the character of the country, the concretionary greensands occupying the high grounds, and the sea-cliffs and lower grounds generally being occupied by greensand marls similar to those described as occurring at Matakana Heads; and, when Waiwera is reached, high cliffs, composed of sandstones, are seen, surrounding the little bay, which are of a brown colour interstratified with thin belts of marl. Coming from the north, one would at once say that these were the same beds as those which I have last been describing at Matakana, and the same remark would equally apply supposing we had reached Waiwera from the south, when we should not be able to discriminate between these beds and those of the Waitemata series. This is perhaps the strongest proof I have of the unity of the Waitemata series and the marly beds which form the base of the greensands farther north; but I do not think that any one travelling through the country from end to end would doubt that the Waitemata beds and these marly greensands farther north belonged to the same formation.

At Waiwera the well-known hot springs are found issuing through these beds, their position being between two faults, the springs themselves, however, being in beds which are lying comparatively horizontally between these. It may be as well to quote the analysis of this water here, together with Dr. Hector's notes on it as published in the New Zealand Handbook for the Melbourne Exhibition. It is "a powerful escape of weakly alkaline and saline water, extensively used as baths in rheumatic and dyspeptic complaints; used internally it has also a mild antilithic action." This spring is largely resorted to, and most comfortable accommodation is provided for visitors.

Analysis.

	Gr. in 1 gal.
Chloride of sodium	116·715
Chloride of potassium	·091
Chloride of lithium	Traces
Iodide of magnesium	Traces
Sulphate of soda	·383
Bicarbonate of soda	87·513
Bicarbonate of lime	10·692
Bicarbonate of magnesia	·954
Bicarbonate of iron	·683
Alumina	Traces
Silica	2·464
	219·495

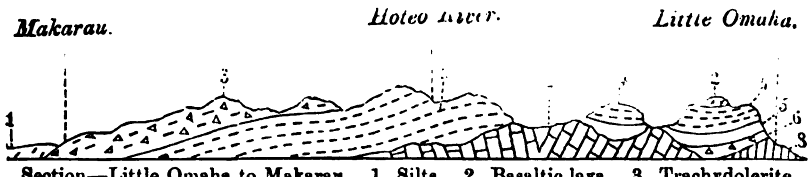
Mahurangi to Mangawhai.

Passing to the north of Mahurangi, we find that, after crossing the ridge of greensands which occur close to the township, we fall into low-lying country at Matakana, and this is composed of marly beds which approximate in character to the Waitemata series; and then, passing over a low saddle in which the concretionary greensands are well seen capping the marls, we fall to the sea-coast, where a spit of silts, No. 2 in the table, is seen. A small patch of volcanic rocks also occurs here, but whether as an outlier of volcanic rocks or a small dyke I am unable to say. They occur on the top of a small hill. After crossing the flat, slates appear, and these stretch round the coast to Little Omaha, a dyke occurring at the point which forms the north head of Whangateau Harbour. At Little Omaha a very instructive section is met with. Resting on the upturned edges of the slates, which are dipping south-west at an angle of 15 degrees, a bed of slate-breccia occurs, which is crowded with fossils—

Ostrea nelsoniana,
Terebratella dorsata,
Rhynchonella nigricans,
Patella, *sp. n.*,
Pecten polymorphoides,
Turbo superbus,
Pectunculus laticostatus,
Lima, *sp.*,
Turbinolia,
Cidaris spines and plates,
Net-corals,
Crab,

being amongst the number. Above this breccia a bed of black marl occurs, with hard concretions, which, while containing fossils, preserves them so imperfectly that no collection could be obtained from them. These are overlaid by coarse concretionary greensands, with which, here and there, are interstratified thin beds of marl. The only place where fossils have as yet been found is at Little Omaha, and from thence to Cape Rodney, throughout which distance they are moderately abundant.

This greensandstone formation then has been traced from Makarau as far north as here, and rests unconformably upon the slates as at Little Omaha and Cape Rodney, or on the limestones as at Mahurangi, &c.; and the following section will illustrate this formation:—



Section—Little Omaha to Makarau. 1. Silts. 2. Basaltic lava. 3. Trachydolerite breccia. 4. Greensandstone. 5. Black marls (glauconitic). 6. Breccia grit (fossils). 7. Hydraulic limestone. 8. Slates.

Passing onwards from Little Omaha in the direction of Mangawhai, the concretionary greensands are met with all along the track until reaching Pakiri, the marly beds occurring along the coast together with the breccias, which, however, appear to be more or less local in their occurrence. From Pakiri north to Mangawhai there is a belt of blown sands about twelve miles long by three or four miles wide, flanking the eastern side of the ranges, which are exclusively composed of the beds of Lower Miocene age. At Te Arai Point slates occur, striking north 30 degrees west, and dipping south-west; and outcrops of slate are reported in the gullies above Pakiri, where I was also informed that a little gold had been got out of a quartz reef which occurs in them, but I did not see either the slates or the reef, although it is quite possible that they both do occur there, since they are found as near as Cape Rodney, and the coast-line north of that.

Mangawhai to Port Albert.

Around Mangawhai there is a considerable flat composed of silts, which flank up close to the dividing range between there and Waipu; and travelling in the direction of Kaiwaka we soon leave these silts, rising on to marly beds which resemble the Waitemata series in character: they are dipping north-north-west at an angle of 10 degrees. These in turn are overlaid by the concretionary greensands so soon as the hills assume a greater altitude, and these greensands stretch uninterruptedly through the high lands to Wellsford, where the hydraulic limestones are cropping out. Descending from the ranges towards the Kaiwaka we find the hydraulic limestones cropping out both along the track and also in the bed of the Kaiwaka Creek, where they dip west-north-west at an angle of 50 degrees, and these are again overlaid by the greensandstones as the first hill is passed along the Great North Road in the direction of Wellsford. After descending into the flats from this hill, the same marls as those which occur at Mangawhai are met with, and these extend to the Hakoru Creek, where the greensandstones come down to the water's edge, and after that, with the exception of one outcrop of the hydraulic limestone, the greensandstones hold until nearly reaching Wellsford.

At Wellsford the hydraulic limestones crop out, and may be traced from there to Port Albert, and thence to the mouth of the Hoteo River, being here interstratified with beds of clay-marl with flints, similar in character to beds which occur above the coal at Kawakawa. They are overlaid between the Oruawharo and Tauhoa Rivers by the greensand marls, and also as they are followed from Wellsford towards Mahurangi the greensands come in, capping them unconformably. There is some report that nickel has been obtained associated with these rocks between Wellsford and Mahurangi, but, with the exception of a greenish-coloured belt of the stone, I was unable to discover anything which could have been taken to represent this metal. In the first branch of the harbour below Port Albert there is an outcrop of cone-in-cone limestone, interstratified with greensands, the relations of which to the hydraulic limestones are not very clearly made out; and in the creek at Wellsford greensands occur with bands of coaly matter, dipping west at an angle of 20 degrees, and overlaid by white sandstone with a few grains of glauconite interspersed, which it seems probable also belong to the greensand beds of the Mahurangi bridge. However, these several outcrops occupy but a very small area, and will not affect the mapping of the country to any great extent, although structurally they have an important bearing on its formation.

Port Albert to Pahi.

Leaving Port Albert we cross the Oruawharo River, and pass over the hills which divide it from the Wairau River, a branch of the Otamatea. These hills are chiefly composed of the hydraulic limestones and clay-marls, being overlaid more inland by the marls, capped by the greensands of the Hakoru River; and descending into the bed of the Wairau we find the limestones stretching from Kaiwaka down to the Waikaki arm, and forming the peninsula on which Batley Township is situated. They are again found on the opposite side of the Arapaoa arm, where they are overlaid unconformably by marly grits, which are highly fossiliferous—

Corbula dubia,	Trochita tenuis,
Lima bullata,	Dentalium, *sp.*,
Pecten fischeri,	Cidaris spines,
„ pleuronectes,	Pleurotoma buchanani,
Cassis muricata (Hect., MS.),	„ trailli,
Pholas,	Waldheimia patagonica,
Tellina,	Fusus, *sp. n.*,
Zizyphinus,	Crab,
Ancillaria australis,	Fan-corals,
Turritella gigantea,	Net-corals,

being found, as well as many other forms. The locality at which these fossils occur is known as Komiti Point, and was in 1874 collected from by Dr. Hector. These marly beds pass up into concretionary greensands, which occur at the northern entrance of the Otamatea, and on the Waikaki side are also capped at two or three points by them. The hydraulic limestones are found at several points up the Arapaoa arm in the low lands along the coast, being capped, in the manner before described, by the greensand marls; and at Pahi beds of greensand occur below the hydraulic limestone, from which, as before mentioned, Dr. Hector has obtained the fossils of the coal measures. Up the Pahi River, at Captain Colbeck's, the Whangarei or Mount Brown limestone occurs, standing almost vertical and forming a curious gorge, known as the Gibraltar Rocks. These beds are unconformable to the hydraulic limestone, as proved by their difference in strike as already noted, and they also are overlaid by the Lower Miocene beds. The hydraulic limestones occur throughout from there to Paparoa and Matakohe, and thence to the Wairoa River, a dyke occurring close to the silts, which stretch from Tokatoka south, past the Awaroa River.

Tokatoka to Maungarahu.

Tokatoka and Maungarahu are composed of porphyritic trachytes, these rocks extending throughout the area. They are, in all probability, dyke rocks, but at Tokatoka they appear to be stratified, dipping north-north-west at an angle of 20 degrees, and at the peak itself and immediately below it a columnar structure has been induced, giving the appearance of bedding. This columnar structure is at right angles to the apparent planes of stratification previously mentioned. The peaks of Tokatoka and Maungarahu rise high above the surrounding country and can be seen for miles around, and between the two and on the Wairoa side felspathic slates occur at the back of Whakahara, from which a little gold is reported to have been obtained. At Jenkins the hydraulic limestones occur, with marly shales lying below them, and here Mr. Jenkins has been boring for coal without as yet any success: the beds are lying unconformably on the slates, and are probably pierced by the dyke rocks of Tokatoka. In the saddle between Whakahara and Maungarahu, marls occur, dipping east-north-east at an angle of 10 degrees, and overlaid by *débris* from the volcanic rocks.

Maungarahu to Dargaville.

Flanking Maungarahu to the northward the hydraulic limestones again appear, and these may be traced northwards as far as Mr. Sutton's, at Arapohue, where they are overlaid unconformably by the consolidated sands which cover the harbour-side of the northern Kaipara Spit from Dargaville south. The hydraulic limestones may be traced inland for about two miles, and at Mr. Webb's farm, which is situated on these, a spring has been discovered which gives off an inflammable gas, and the water from which destroys the vegetation along its course. It was supposed to indicate the presence of petroleum, but I do not think it can be considered as of any value from that source, as the escape of gas is too small to indicate anything of importance, and carburetted hydrogen would be evolved from a number of causes. The water was saline to the taste, and the spring was situated in a swamp. In this direction the hydraulic limestones are overlaid by the greensand marls which extend to the Mangonui River.

Tokatoka to Waipu.

To the east of Tokatoka the volcanic rocks are flanked by a southern extension of the greensand marls. These latter are arranged as a syncline, and lie unconformably on the chalk-marls. They are of but little extent, the distance between Tokatoka and a small dyke at their junction with the chalk-marls being less than a mile. The chalk-marls and hydraulic limestones are largely developed to the eastward, extending some six miles in the direction of Matakohe, and, contrary to their usual mode of occurrence in low grounds, they form all the higher surfaces of this great area. Their strike, as determined at their western extremity, is north 55 degrees west, and their dip south 35 degrees west at an angle of 30 degrees.

About midway on the track from Tokatoka to Matakohe, and on the west side of what is locally known as the "Bridge," a small outlier of volcanic boulders occurs, lying on the chalk-marls.

Passing eastward the chalk-marls are again overlaid by the greensand marls, and do not again appear until Matakohe is reached, whence they extend westward to the Wairoa River and eastward about a mile beyond the Matakohe bridge, where they disappear below the greensand marls. These latter beds extend to Mr. Skelton's farm, above the Paparoa bridge, where they lie unconformably upon the upturned edges of the Mount Brown limestone, which occupies the large hill on the north side of the Pahi River, opposite Captain Colbeck's. This limestone is subcrystalline and very hard; it is generally of a flaggy, coarse, and granular structure; it is often fossiliferous, but the fossils are very difficult of extraction, and on its weathered surfaces numerous fragments of spines of Echinodermata and corals are seen. It dips north-west here at very high angles.

From Paparoa the hydraulic limestones sweep round to Maungatoroto, and embrace a very large area, and about a mile north of Maungatoroto on the road to Waipu they again disappear under the greensand marls. This point would seem to be their limit in this direction.

At Pukekorero, near Maungatoroto, there are some grey felspathic ashes and dyke rocks which have assumed a columnar structure, and bear a marked resemblance to the Tokatoka rocks; they appear to be associated with the concretionary greensands there. These greensands extend to the north-east about two and a half miles beyond Little's store, that is, almost to the watershed of the Maungatoroto and Waipu Rivers, where they are cut off by the Te Anau slates, which form all the high rugged bush country to the north and south of this point. These slates are of a dark-red or green colour, and when exposed to the weather decompose very readily; they extend about three miles down the Waipu Gorge, striking north-west, and dipping north-east at very high angles. The slate ranges extend northwards to the Tangihua or Blue Mountains, and also towards the Mangawhai Heads. They are said to contain gold in small quantities.

Mangawhai to Whangarei.

The Mangawhai North Head is composed of slates with beds of greensandstone resting on them which very possibly belong to the Lower Greensand beds, but I have no information concerning them which will tend to elucidate that point. As we pass northwards we find that, before reaching the Cove, beds of green and brown sandstone come in, which are lying unconformably on the slates, and at the Cove these are overlaid by the Whangarei or Mount Brown limestone, so that they probably are the greensand beds of the coal measures. At the Waipu River the slates come down to the coast, and from there a flat composed of silts extends as far as Ruakaka, where the consolidated sands of the Whangarei South Head come in. Flanking the slate ridge on the eastern side, the greensand beds of the coal measures stretch uninterruptedly to Mangapai, and thence to Whangarei, where they are split and lap round the two sides of the slate ridge. At Morrison's, about eight miles from the Township of Waipu, limestones again occur, which rest indiscriminately on these greensand beds with coal, and on the slates and in the greensands here the fossils of the coal measures are found. There are some very fine caves in the limestone at Morrison's, with some splendid stalactites and stalagmites.

The district around Whangarei has already been described (Geological Reports, 1876–77) : so I shall not reproduce the work here.

Dargaville to Tangiteroria.

It yet remains to mention the district from Dargaville up the Wairoa River. Around Dargaville very extensive deposits of the consolidated sands occur, and these rise to an altitude of 200 or 300 feet on the hills towards Tutamoe, where they rest upon another outcrop of the hydraulic limestone, while the volcanic rocks of Tutamoe, Tongariro, &c., of intermediate age, bound them to the northwards. Up the Wairoa River the Miocene greensands occur, until McGregor's farm is reached, where slates crop out on the banks of the river, and from a short distance above this point to Wilson's Landing the micaceous sandstones, &c., from which we obtained *Inoceramus*, are seen, but overlaid by recent river deposits at most places. Above Wilson's the slates which form the Tangihua Mountains come in and stretch to Tangiteroria, and thence north, the road to Whangarei cutting across them. The Wairoa River is fringed on either side by flats which are of considerable extent, and the river as it bends and twists through these in its course has made natural fences for many acres of good land, which, if not liable to heavy floods, will be some day of great value. North-west of the Wairoa River two volcanic cones, Te Houtoa and Maungatipa, occur, belonging to the basaltic series; but their position is very inaccessible, and the bush in this district generally precludes any detailed work.

General Remarks.

I have now to review the general results of this work, and my report will be done.

Perhaps the most important result which has been attained during this trip is the correlation, on stratigraphical grounds, of the Waitemata series with the concretionary greensand and underlying marly beds which occur farther north, and which yield fossils at their base, clearly proving them to be the equivalents of the Pareora beds of the South Island; and the bearing which this will have on the probable extent of the coal measures is most important.

Dr. Hochstetter, in his lecture on the Geology of Auckland, considered these Waitemata beds to be the next above the brown-coal formation of the Waikato, and, subsequently, in his report of the "Novara" expedition, placed them as older marine Tertiary.

Captain Hutton, in his report on the Lower Waikato District, places them at the top of the Tertiary formations as Pliocene; and, in my report on the Waikato District, I considered these beds as occurring at Mercer to be the upper beds of the Leda marls, and of Cretaceo-Tertiary age. There is, no doubt, considerable evidence about Mercer to favour this last conclusion, since the beds of the Waitemata series there appear to pass down in direct sequence to the Leda marls, with numbers of *Pecten pleuronectes,* and also themselves contain nummulites of the same class as are found in the Leda marls elsewhere. In the face, however, of the proof which I have gathered during my northern work, including the occurrence of *P. pleuronectes* with the Lower Miocene fossils at Komiti Point, I am bound to place the whole of the Waitemata series, as developed around Auckland and to the north of that place, as the equivalents of the Pareora beds, and of Lower Miocene age. Below these beds the chalk-marls with flints, and hydraulic limestones, occur unconformably, and they bear a marked resemblance to those beds which overlie the coal at Kawakawa, at which place beds of greensand and Teredo limestone intervene between them and the coal, representing the greensands which form the roof of the coal at Whangarei, and the sandstones which form Mount Tiger, and occur further south to Waipu. From this it may be seen that the coal measures themselves may be traced more or less continuously from Kawakawa through Hikurangi to Whangarei and thence to Waipu; and mines are now being worked at Kawakawa and Whangarei, two being in operation at the latter place. It will be interesting to note the analyses of the coals from these different mines.

Bituminous Coal, Kawakawa.

No. 1. Hard, and very coherent. Powder brown. Coke sets very hard, close-grained and dull; ash white and alkaline.

No. 2. Moderately hard, but easily crumbles. Powder black-brown. Coke hard, but puffs a little; lustre vitreous; ash faint pink colour.

Analyses.

	No. 1.	No. 2.
Fixed carbon	39·97	39·29
Hydro-carbon	52·44	54·43
Water	3·39	3·53
Ash	4·20	2·75
	100·00	100·00

Glance Coal, Kamo, Whangarei.

A moderately hard, compact coal; colour of powder black-brown. Coke frits a little; ash white.

Analysis.

Fixed carbon	50·11
Hydro-carbon	38·68
Water	8·01
Ash	3·20
	100·00

Glance Coal, Whauwhau, Whangarei.

Hard and lustrous, slightly pyritous; colour of powder black-brown. Coke non-caking; ash white.

Analysis.

Fixed carbon	42·20
Hydro-carbon	44·87
Water	9·12
Ash	3·81
	100·00

Farther south than Whangarei no mines have been opened, although coal is known to exist at the Ruakaka, and this place is the farthest south to which it has yet been traced. The occurrence of the hydraulic limestones, clay-marls, &c., however, on the western side of the slate ridge, at various places in the Kaipara Harbour, and as far south as Mahurangi, makes it quite possible that coal will yet be discovered in that district; but the high angles at which these beds are generally standing there is certainly unfavourable for the occurrence of workable seams, and, unless some district is discovered in which these beds have a flatter dip, it does not seem probable that coal deposits of importance will be found. Mr. Jenkins has been boring for coal through these beds at Tokatoka, and Mr. Sutton was proposing to do the same at Arapohue; but at the latter place the dip of the beds is very high. The other points mentioned in my report do not call for any further notice, but I must not conclude without mentioning the assistance afforded me by Mr. Park in the details of this work, as, in addition to his duties as collector, he was engaged from time to time mapping certain portions of the district, while I was absent on my work as Inspector of Mines, and to him I am indebted for the descriptions of those areas.

3rd May, 1880.

MATAURA PLANT-BEDS, SOUTHLAND COUNTY.

REPORT BY ALEXANDER M'KAY.

INSTRUCTIONS.

IN a memorandum of instructions, dated 1st August, 1879, I was directed, in commencing the field work of the present season, to proceed to the Mataura Falls, Southland, and there examine and collect from the Middle Secondary strata yielding fossil plants at that place; and at the same time specially directed to ascertain the precise position which these beds should occupy in the sequence of formations which had already been determined in the neighbouring Hokanui Hills. For this purpose it was suggested that an examination of the left bank of the Mataura River, from the railway bridge near the Township of Gore to the junction of the Wyndham River with the Mataura, should be sufficient to determine the point in question. And finally, in reporting the results of this work, in tabulating the various strata I was directed to make use of the classification already adopted for the same beds in the Hokanui Hills.

NARRATIVE.

I HAVE the honor to report that I left Wellington for the Mataura Falls on the 1st of September, 1880, and by the 5th of the month reached my destination. During my stay at Mataura I made a considerable collection of fossil plants, worked out the relations of the plant-bearing beds with the associated strata, and in addition discovered and collected from shell beds associated with the thick beds of Tertiary lignite which are extensively developed on the plain between Gore and Edendale.

On the 13th of September I left the Mataura District for Clinton, and spent the following days till the 17th in that neighbourhood, during which time I made a small collection of fossil plants from Lower Trias or Permian beds in the Popotuna Gorge; and on the 17th of September I returned to Dunedin.

REPORT.

At the Mataura Falls I found some difficulty in discovering the particular horizon yielding distinct plant-impressions, and, on the east bank of the river failed to find a single example of that particular form, *Macrotæniopteris lata*, which renders unique the plant collections formerly made from this locality.

It so chanced, unfortunately, that at the time of my visit the river remained flooded to such an extent as to cover the greater part of the tabular rocks between the main fall and the paper-mill on the eastern bank, so that the particular horizon containing the more important plants remained constantly covered by a considerable depth of water. Finding fossil ferns in strata considerably overlying the particular beds at Mataura Falls, I examined these closely, hoping that in them the main object of my search might be found, but was not successful.

The strata succeeding the beds at Mataura Falls, and forming the higher part of the series to which both belong, are essentially lacustrine, and everywhere are crowded with plant-impressions; but at almost all points the plants are so imperfectly preserved, or consist but of stems and branches of large plants, that distinct impressions can but seldom be obtained, and these latter, occurring in a light-coloured friable shale, are difficult to extract in anything but very small specimens.

The plant-beds which are found underlying the particular horizon of the Mataura Falls have a like character to those just described as overlying, and but seldom yield distinct impressions of the finer parts of the plant. In many places large tree-like masses are of not infrequent occurrence in these lower plant-beds.

Not finding as readily as I expected the particular beds sought for, I commenced a detail examination of the right (or west) bank of the river from the bridge upward; but no distinct impressions of ferns were found until the sandstone bed forming the ledge over which the river falls was reached.

Here, in a fine-grained sandstone, plants within a limited space were very abundant, and generally well preserved, so that at this point I was enabled to make a good collection, more especially of the large fern, the main object of my search. The mode of occurrence of this particular fern was so peculiar that, taken with other facts which I had already observed, I came to the conclusion that the plants had actually grown upon the very spot and layer upon which they now rested.

From the Mataura Bridge, at the township of that name, to the falls of the river, a distance of about three hundred yards, the rocks consist of alternations of a green coarse-grained sandstone, and dark-coloured sandy beds of a more shaly character, the upper surface of these latter beds being often full of the rootlets of plants. The partings between these and the immediately overlying greensandstone beds, which contain plants but rarely, and never any rootlets, are sudden and distinctly marked. Thus it is not difficult to conceive that the finer-grained beds containing rootlets piercing them vertically, indicate these to be old soils, which, on being submerged, were buried beneath the next overlying bed of sandstone.

The absence of water-plants among the flora already collected may be taken as indicative of the terrestrial character of these plant-growing surfaces, and this supposition falls not short of certainty when to this we add the evidence obtained from the plant-bed in which *Macrotæniopteris* is found.

In this part of the section the stratum in its bedding is smoothly even; but where the plant collections were made at the falls there were a number of flatly conical elevations, in the centre of which hard sandstone and coaly matter were mixed in nearly equal proportions. Around these elevations the *Macrotæniopteris* fronds were almost without exception so arranged that the base of the frond lay nearest to, or was almost attached to, these central bosses, the apex of the frond dipping away to a lower level—a curious fact, evidence of which may be seen in several of the specimens collected. In these the planes of stratification of the rock and that in which the plant lies are not the same, which may be accounted for only by the frond lying on an uneven surface, or hanging from the parent stock in such a manner that the horizontal planes of the accumulating sediment and that in which the plant lay were not the same.

The elevations already mentioned were arranged in a row, some four or five of which were observed; and all the specimens of *Macrotæniopteris* were obtained from the near vicinity of one or other of these, arranged radially around them, as already pointed out. I cannot therefore doubt but that these little mounds, with their comparative excess of carbonaceous matter, represent the roots and stock upon which the specimens collected once grew, and, as a consequence, that this must truly have been a land surface.

The position in section which the plant-beds at the Mataura Falls occupy being neither the highest nor the lowest exposed with apparent conformity along the banks of the river, I had first to examine the section upwards to the highest beds of the sequence, and, this done, the underlying beds, as far as they are seen, between the Mataura Bridge and the junction of the Wyndham River with the Mataura.

The upward sequence ended in a syncline, beyond which, to the north or in a direction following the river upwards, the whole of the strata elsewhere seen were again exposed; and, in addition, in this direction, a very considerable thickness of beds, embracing two or more distinct groups of strata lower than any of those as yet examined, made their appearance. Hence, from the disjointed way in which the work was accomplished, I must abandon the narrative and detail the results of their examination in a systematic manner.

The following is a table of the different formations recognized as occurring in the district over which my examinations extended:—

Table of Formations.

Age.	Formation.	Principal Locality examined.
Lower Miocene	Pareora Formation	Mataura lignite pits and bank of the river.
Upper Jurassic	Mataura Series ...	Near Mataura Bridge.
Lower Jurassic	Putataka and Flag Hill Series	East bank of the Mataura River, four miles above the falls.
Liassic ...	Bastion Series ...	Mouth of the Wyndham River.
Upper Trias ...	Otapiri Series ...	East bank of the Mataura River, between Mataura and Gore.
Middle Trias...	Wairoa Series ...	East bank of the Mataura River, opposite Gore.
Permian ...	Kaihiku Series ...	Northern slope of the range between Gore and Clinton.

In a former report—Geol. Reports, 1877–78—the beds forming the Hokanui Hills have been described, and shown to consist in the eastern part of the district of a great assemblage of strata arranged as a syncline, which on the northern side, from the lowest to the highest beds, dip at very high angles, while on the southern side of the syncline the dip is everywhere at a very moderate angle. The syncline thus raised in that direction drops bed after bed as it is followed to the westward, the highest bed leaving the northern side of the syncline near Mount Peel, no higher beds appearing along the trough of the syncline to the eastward.

The high downs, and a plain of considerable extent which lies between the eastern end of the Hokanui Hills and the Mataura River, being composed of recent and Tertiary strata, hide over this space the older rocks of the Hokanui Hills, but they reappear along the eastern bank of the Mataura River with exactly the same arrangement which they have along the section G–H of Mr. Cox's report, and, as nearly as may be, each particular group of beds are as exposed directly coincident with the direction in which they were striking in the Hokanui Hills.

The highly-tilted strata composing the north side of the syncline form the country north and east of a line drawn from the centre of the syncline three miles above the Mataura Falls to False Island, near the mouth of Catlin's River, the limits of the Secondary and Permian formations in this direction being south of the railway-line as far as Clinton, and south-west of a line drawn from Clinton to Molyneux Bay. On the southern side of the syncline the higher formations, including the Lias, cover all the country between the

Mataura and Catlin's River, none of the older rocks forming the lower beds on the northern side of the syncline making their appearance.

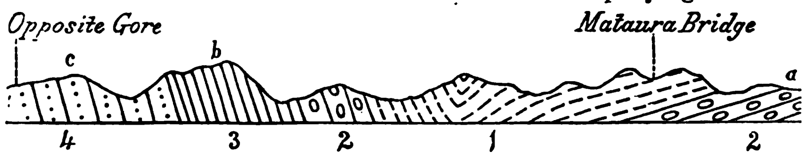
Kaihiku Series.

These rocks are undoubtedly present on the eastern bank of the Mataura River opposite Gore, and form the hills to the north of the railway-line for some distance to the eastward. But neither here nor at the Popotuna Gorge, where they are also present, do they appear to be fossiliferous. The beds, however, were not closely examined; and, as in the Hokanui Ranges, they may yet, on closer examination, prove to be richly fossiliferous.

Although considered to underlie the Wairoa formation unconformably, the Kaihiku series is so often present in the near vicinity of exposures of the Wairoa formation that, where the one is found, the other series may fairly be expected to occur in the same neighbourhood.

Wairoa Series.

The Oreti series, which in the western end of the Hokanui Hills separate the Wairoa beds from the Kaihiku series, are in all probability continued through the eastern part of the Hokanui Hills to the left bank of the Mataura; but, like the Kaihiku series, they appear to be unfossiliferous in this direction. The lowest fossiliferous horizon which I detected in the accompanying section



Section along east bank of Mataura River. 1. Mataura series (*Macrotæniopteris* at base). 2. Flag Hill series (fossils at *a*). 3. Bastion and Otapiri series (fossils at *b*). 4. Wairoa series (fossils at *c*).

examined along the left bank of the Mataura may possibly belong to the Oreti series; but as none of its peculiar fossils are present in the beds, and those which do occur are common to the lower beds of the Wairoa formation, I have, for this and another reason, referred the beds to the Wairoa series.

The further reason for considering the lowest fossiliferous beds of the Mataura section as part of the Wairoa series is that between this and the next overlying beds in which fossils were found a considerable part of the Oreti series and the whole of the Wairoa series were present. As the second fossiliferous bed marks a definite horizon, it would be necessary to conclude that both the Oreti and Wairoa formations are considerably less in thickness than in the Hokanui Hills.

The fossils obtained from the lower beds of the Wairoa series belong to one species only—a species of *Athyris* occurring in great quantities in a sandstone rock, associated with indurated sandy shales, rocks generally characteristic of this horizon.

In following the sequence upwards, no further fossiliferous bands were detected in this formation, but the *Monotis* sandstone closing the series was so distinctly stamped with its peculiar characteristics that even had the succeeding beds proved unfossiliferous there would have been no difficulty in recognizing it. Plant-remains were less abundant in it than elsewhere; but the rock is the same coarse brown sandstone, passing into pebble beds, which may be seen at the Oreti Railway Station, and equally well as in Mount Wellington, on the south side of the Wairoa Gorge, Nelson.

Otapiri Series.

In this line of section, as almost everywhere else, the *Monotis* sandstones are overlaid apparently conformably by the lowest beds of the Otapiri series, these being dark or rusty-coloured sandstones, generally of finer grain than the underlying *Monotis* sandstone.

One and a half miles below Gore, the spur of a hill, on the eastern bank of the Mataura, runs down as a bluff, close to the water's edge. The northern side of this bluff is composed of *Monotis* sandstone, while its southern slope, looking down the Mataura River, exposes the same beds with the same fossils which are found in the Oreti Railway cutting. I collected at this point the following fossils:—

Belemnites otapiriensis, *Hector.*
Spiriferina spatulata, *Hector.*
Clavigera tumida, *Hector.*
Rastelligera taylori, *Hector.*

Had the beds been followed, or more exhaustively collected from at the point whence the above fossils were obtained, it is probable that a much greater variety of fossils would have been collected. My principal object being to identify the beds at this point, I did not consider it necessary to make large collections from the beds, which have been well nigh exhaustively collected from already.

The character of the rocks and the thickness of the strata which must be considered as belonging to the Otapiri series are very similar to what they are in the Hokanui Hills; but from the want of fossils in the upper part of this series the boundary dividing this from the next overlying formation is not easily determined. Like the underlying formations already described, the beds belonging to the Otapiri series are all standing at high angles, the dip being in a southerly direction.

Bastion Series.

Rocks belonging to this series are the next succeeding the Otapiri series in following the Mataura along its eastern bank from the railway bridge near Gore southward. The disposition and character of the rock are similar to those of the underlying beds already described. Fossils were found at one point only, and these proved so obscure that their specific character could not be recognized. As far as those could be made out, the character of the rocks in which they were found, and the position of such rocks as regards their relation to the underlying strata, and also in some measure to the overlying beds, show that this band of fossiliferous rock represents the lower part of the Middle Ammonite beds in the western part of the Hokanui Hills along the banks of the Otapiri Stream. This is the last fossiliferous horizon in the northern end of the section until the syncline is passed. This group also is the lowest that makes its appearance on the southern side of the syncline, where near the mouth of the Wyndham River are seen black marly strata corresponding in position and identical in character with the lowest beds of the Bastion series in their typical locality — the middle part of the Otapiri Valley, near Taylor's Crossing. These black marls were not detected in that part of the Mataura section north of the syncline, where they might be looked for. On the northern bank of the Wyndham River these were overlaid by the lower part of the Middle Ammonite beds—a superior member of the Bastion series which has already been mentioned as containing fossils in the northern part of the section. These latter beds are however more abundantly fossiliferous on the banks of the Wyndham River, where the rocks composing them consist of sandstones and occasional beds of fine-grained conglomerate. In the sandstone beds I collected specimens of a small *Cardium,* also found in the black marls of the Wyndham River, and, in addition, *Astarte minima,* a small *Pecten,* with *Ostrea, Tancredia,* &c.

From the Mataura Falls, following the river down, the strata dip to the north at low angles till the Wyndham River is reached, exposing from beneath the plant-beds at the falls a considerable thickness of strata, which embraces the Putataka, the Flag Hill, and the greater part of the Bastion series; but, a low anticline taking place along the course of the Wyndham River, it is not probable that lower beds would be found were the Mataura followed further in the direction of the mouth of the river.

Putataka and Flag Hill Series.

From the absence of fossils it has not been possible to discriminate between these two formations. In fact, it is questionable if the higher of these, the Putataka beds, are separable from the Mataura series in this section; but, as elsewhere they have been considered to form a distinct horizon between the Flag Hill and Mataura series, I have for this reason included it in the present classification. But as the fossiliferous beds belonging to the middle part of the Flag Hill series underlie the plant-beds at the Mataura Falls by not more that 200 feet, there may be but little propriety in introducing the Putataka series at all.

Following the northern part of the section south from the point at which fossils referred to the Bastion series were found, no distinct fossils, either shells or plants, were found, until the south side of the syncline was reached; so that the beds proving the presence of the Flag Hill series have to be looked for on the south side of the syncline, some distance below the Mataura Falls. As it will be unnecessary again to refer to the beds on the northern side of the syncline, it remains but to say that both this and the next overlying series—the Mataura series—are present, but being unfossiliferous they lend no assistance in determining the position of the plant-beds at the Mataura Falls.

Following the section northward from the right bank of the Wyndham River, for several miles the low grounds along the east bank of the Mataura River, forming an alluvial plain, break the continuity of the section, and not till within four miles of the Mataura Falls are rocks again seen along the banks of the river. The dip of these rocks varies between 25 degrees and 30 degrees; the rocks themselves presenting characters agreeing with those which distinguish the lower part of the Bastion series, so that we must infer what, from the appearance of the country to the eastward, may reasonably be considered the case—that a roll or low anticline, with a corresponding syncline, is present between this point and the mouth of the Wyndham River.

The Wyndham anticline not exposing rocks lower than the base of the Bastion series, the intervening twelve miles between there and the Mataura Falls would represent a far greater thickness of strata than can be accorded to the formations present between the two points, unless the angle of dip be generally much lower than that observed, or another anticline with a corresponding syncline be present. It is therefore more than probable that the dark marly sandstones, which are seen in the banks of the river four miles below the falls, are the equivalents of the Wyndham marls, and as a consequence the immediately succeeding rocks which follow conformably can with safety be referred to the middle and higher parts of the Bastion series. Accordingly we find, in direct sequence to these marls, the coarse sandstones full of indistinct impressions of plants and silicified or carbonized wood, which form an important member of the Middle Ammonite beds in the Hokanui Hills. Again, overlying these are beds which present the characters of the upper member of the Bastion series, and the total thickness of these two divisions of this formation I estimate at much the same number of feet which would measure their thickness in the typical locality.

About one mile below the Mataura Falls the highest beds of the Bastion series are overlaid by fossiliferous sandstones, which give us the means of determining the exact horizon to which they belong.

The fossils collected include — Specimens of ***Belemnites catlinensis*** (Hector); ammonites, of which one fragment only, a large specimen of the *Plagiostoma* characteristic of the fossiliferous beds at Bloody Jack's Island; a *Plicatula* common in the Upper Spirifer beds of the Flag Hill series; the same *Ostrea* that occurs so abundantly at the mouth of Catlin's River; and, in considerable numbers, the shell which has given its name to Pholodomya Point, on the coast between the mouth of Catlin's River and Nugget Point. There are also found in the sandstones from which the above fossils were obtained considerable numbers of a small-eared *Pecten*, which is either smooth or finely marked with concentric lines, presenting the general appearance of *Pecten obovatus*, the characteristic shell of the black grit in the Amuri section. This latter shell has only as yet been found here at Bloody Jack's Island, and in the Lower Belemnite beds on the north face of Flag Hill.

I have, in consideration of the presence of the above fossils, no hesitation in pronouncing this bed as the equivalent of the Lower Belemnite bed in the Flag Hill series; and, as not more than 200 feet of strata intervenes between this bed and the plant-beds at the Mataura Falls, the actual horizon of these latter may be guessed at with some degree of certainty. But whether these 200 feet or at most 250 feet of strata, which intervene between this recognized horizon and the plant-beds, may be taken as representing the greater part of the Flag Hill series, and the whole of the Putataka beds as well, appears somewhat questionable. This circumstance, coupled with the fact that the Mataura plant-beds have a claim to be included with the Mataura series, induced me to associate together the Putataka and the Flag Hill series; otherwise the Putataka and the Mataura series are in this district equivalents of each other.

Mataura Series.

These beds have already been partially described in speaking of the plant collections made from them at the Mataura Falls. There is no unconformity between this series and the next underlying, and, therefore, where the boundary separating the two shall be placed is simply a matter of little consequence, provided the higher series shall include the plant-beds. A marked difference in the character of the strata takes place just at the point where the bridge spans the river, dark-coloured marls there underlying the coarser sandstones, which wall in the river between the bridge and the falls: this I have taken as the lower boundary of the Mataura series. From this point to the centre of the syncline, fully three miles further up the river, the rocks are chiefly sandstones, dipping at a low angle in a northerly direction, and nearly everywhere these contain plant-remains abundantly. Near the the centre of the syncline, the low angle of dip is increased on the southern side, and, as already observed, all the beds of whatever formation is exposed on the northern side stand at high angles.

The plant-beds at the falls of the river above the bridge are therefore in position near the base of the Mataura series—an amount of strata difficult to estimate, but not greater than the total thickness of the Mataura series in the Hokanui Hills overlying the plant-beds.

The only serious difficulty which I have had to deal with in determining the position of the strata in this section has been the impossibility of placing correctly the Putataka formation; but, this being a matter of secondary importance only, the prime object of the examination may be considered as having been accomplished.

Pareora Formation.

Rocks of this age cover a considerable area west of the Mataura River between Gore and Edendale, but in the low grounds for some distance back from the river are wholly obscured by recent alluvium, and the very existence of such strata had as yet been unknown but for the natural sections seen along the banks of the Mataura, and in the deep gulches which the creeks cut into the plain near their junction with the river. Referable to this series are the high downs, composed of quartz, gravels, and fireclays or fine sandy beds, which skirt the eastern termination of the Hokanui Hills. These, in a former report, I have referred to the Cretaceo-Tertiary series, and it is still possible that they are not of the same age as the Mataura lignites, the age of which I have succeeded in determining.

Near the Mataura Bridge a thick bed of lignite is at present being worked by Mr. Angus, of Invercargill, and large quantities of this mineral are being used, not only in the neighbourhood, but also in Invercargill, as fuel.

A thick bed of greenish sandy clay underlies this upper main bed of lignite, beneath which a second bed of lignite crops out on the banks of the river. This second bed of lignite is underlaid by green and grey marly clays, which are well exposed on the west bank of the Mataura for a mile down the river from the bridge. In their lower part these are fossiliferous, which fossiliferous bed is underlaid by a third bed of lignite (very impure), resting, as seen in the bed of the river, on quartzose sands of no great thickness, which in turn, as the lowest bed of the series, lie on Secondary rocks belonging to the Flag Hill series.

The fossils obtained from the marly strata interbedded with these lignites show that the lignites belong to the Pareora formation, and are the same in age as the lignites and shell beds of the Pomahaka River. Recent forms of *Struthiolaria*, *Turritella*, and *Crypta*, *Ostrea*, *Mytilus*, &c., are associated with *Pecten hochstetteri*, *Cerithium nodulosum*, *Corbula dubia*, and other extinct forms, leaving little doubt to what age the beds should be referred.

DISCOVERY OF CHALK NEAR OXFORD, ASHLEY COUNTY.

REPORT BY ALEXANDER M'KAY.

Part of my instructions for the present year directing me to examine the Ashley Gorge and Upper Ashley District, on my return thence I had occasion to pass through the Town of Oxford. While there, I was shown by Mr. John Ingram a sample of white rock, which he told me occurred abundantly on his property at West Oxford, eight miles distant. The character of this rock admitted of no mistake in determining the nature of it, being evidently a very fine description of chalk. From Mr. Ingram I learned that he forwarded samples of this rock to Professor Von Haast, who reported that it was a limestone of excellent quality.

Deeming this discovery important, not only as likely to affect favourably the interests of the district in which it had been made, but also from a geological point of view, I determined to visit the locality where this chalk had been found. Accordingly next day I went with Mr. Ingram to West Oxford, and spent that (the 29th of October) and the day following in ascertaining the relation of this chalk to the strata exposed in the immediate neighbourhood. While prosecuting this work, I ascertained from Mr. Ingram that, in as far as the existence of calcareous rocks in this locality was concerned, the discovery was not a new one. Some years ago a section of land situate on the northern bank of the Eyre River, a mile distant from the point marked by the present discovery, was purchased for the express purpose of turning to account the calcareous strata supposed to be present. The limestone, such as it is, proved too poor to render the burning of it a success, and after a preliminary trial the idea was abandoned; nor, from the inferior character of the deposit attempted to be worked, is limeburning at this point ever likely to be a success unless stone of better quality should be discovered. As far back as 1873 I recollect being told by the late Mr. Fuller, then taxidermist to the Canterbury Museum, that chalk, containing minute shells, and other fossiliferous strata, were to be found in the western part of Oxford Bush, he having observed such while there for a supply of birdskins in connection with his special profession. I readily believed this statement at the time, as prior to that date I had been shown by Mr. White, one of the oldest settlers at Oxford, a fossil shell, *Conchothyra parasitica* (McCoy), which he assured me had been picked up in the bed of the Eyre River, thus proving an extension of the Malvern Hills coal field, or rocks of the same age, in this direction.

But to return to the chalk. The exposed portion of the bed crops out on the northern end of a low bush-clad ridge, which is broken through by a small creek coming from the north-west, which joins the Eyre at Ingram and White's saw-mill. The valley of this creek separates this ridge from an apparent continuation to the north-east of the strata which compose it. To the south-west this ridge continues unbroken till it abruptly terminates, a mile distant on the banks of the Eyre River. The river here, turning to the north-west, thus runs along its south-east face and western termination.

In the same line View Hill stands some distance beyond the Eyre on the adjoining plain, and is composed mainly of volcanic rock, which also forms the eastern slopes of the chalk-bearing ridge. On examining the outcrop near the saw-mill, it showed every indication of being part of a bed of considerable thickness. It was at this point traceable transversely to the direction of its strike for a distance of 40 to 60 feet, without being directly overlaid or underlaid by rocks of a different character. To the north-east it crops out in the bed of the stream coming from the north-west, which crosses its strike in this direction, and is, without doubt, for some distance further along the same line.

I have already mentioned that—at the surface at least—it terminates in a westerly direction with the ridge of which it forms a part, and that in this direction its quality is not equal to what it is at the north-eastern end of the ridge.

Near the saw-mill no solid rock was found in direct contact with its upper surface, but great quantities of vesicular volcanic rocks, and others of a denser and more crystalline structure, are strewn along the south-eastern slope of the ridge, indicating that these are the next overlying rocks. On the banks of the Eyre, at the western end of the ridge, these rocks are seen to overlie unconformably the inferior marly chalk there exposed.

It may not be quite certain that the chalk-marls seen at this latter place are the actual horizontal equivalent of the bed seen cropping out near the mill, and it is possible this purer chalk belongs to a lower horizon, the higher beds being unconformably overlaid and obscured at this point by the volcanic rocks. The direction and amount of dip could not be determined by an examination of the chalk strata; but, the associated underlying beds dipping to the south-east at angles varying from 25 degrees to 30 degrees, the chalk is not likely to have a much higher dip. Judging from what could be observed at the time of my visit, I estimated that the total thickness of the chalk could not be less than 100 feet. Since then it has been laid bare for a distance of six chains in a direction north-west and south-west, or transversely to the associated underlying strata.

I had quarried from the outcrop near the saw-mill a large block some 4 feet square, from which were cut two cubes 18 or 20 inches square, which, with several smaller pieces, have been deposited in the Colonial Museum. These examples are remarkably fine and uniform in grain, of snowy whiteness, compact and strong, yet soft enough to be unrivalled as material for using as crayons on the blackboard. Crayons 5 or 6 inches in length, having a diameter of not more than a quarter of an inch, can in this manner be used freely without danger of fracture.

By analysis this chalk yielded from 82 to 94 per cent. of carbonate of lime (Fifteenth Laboratory Report, 1879–80, p. 34).

In spite of a supposed deterioration of this chalk as it is followed in a westerly direction, there is practically an unlimited supply of it to be obtained in the neighbourhood of the outcrop whence the sample yielding the best analysis was taken.

Applied to the many purposes for which chalk is useful, whether these be the immediate wants of the district as common lime, &c., or in its more special application as a principal ingredient used in the manufacture of Portland cement, it is alike important.

The limes hitherto used in Northern Canterbury have been mainly derived from two sources—the Amuri Bluff, in the Marlborough Provincial District, and the western part of the Malvern Hills. In the first locality the supply of stone, though unlimited, has to be conveyed by means of boats to the vessel in the offing, a work which is often long delayed on account of the open character of the roadstead at that place rendering its shipment not at all safe. From hence it has to be conveyed by sea and river carriage to the limekilns situate on the Heathcote River, a few miles east of Christchurch, where it is burned with coal imported from New South Wales, or from the west coast of the South Island.

Lime is burned in Southern Canterbury and Northern Otago principally to meet the local demand within those districts, the export of lime from these districts not having interfered with the comparative monopoly which Amuri lime has hitherto enjoyed in Christchurch. Dunedin drawing large supplies of lime from the quarries situate at and near the Waihola Gorge, this, when exported to Christchurch, can do no more than compete with the other sources of supply upon much the same terms. The source of supply, and the reduction of the stone to quicklime, are so beset with difficulties in the Malvern Hills that, although the locality is nearer to Christchurch than any of the others already mentioned, this cannot do more than obtain for itself a limited share of patronage, and at the same time satisfy local demands. The stone here used is obtained from the Four Points Range, on the south side of the Selwyn Gorge. The stone, which is a hard variety of limestone, sometimes denominated marble, has to be carted seven miles to the kilns at present used for burning it. Strange to say, that in a district abounding in coal the fuel used in the reduction of this stone is imported coal, which has to be brought from Christchurch by railway. However much stone may be burned there, the Malvern Hills supply can have little tendency to cheapen the cost of lime, and at the same time leave a fair profit to the producers.

Seeing that eventually the consumer must sustain the full weight of these heavy costs in the high price which he pays for his lime, the production of a less costly article, while not lessening the profits of the producer, by so affecting the price of the article must render profitable the application of lime to many purposes for which at present it does not pay to use it.

The Oxford chalk is the only deposit at present known which is likely to exercise this effect within the Canterbury Provincial District. The ease with which it can be reduced to a quicklime renders available for this purpose the abundant supply of timber which the surrounding forest affords. The stone can be raised and the timber supplied from higher levels than the place where these are likely to be used. A projected railway line passes within some four or five miles of the locality, and will thus afford a cheap means of transit to other parts of the district, while a populous agricultural neighbourhood will at the same time be benefited.

Apart from these advantages which this discovery is likely to confer on the people of Canterbury, it has yet a wider application, and one in which the whole colony cannot but be interested. This is the likelihood of its leading to the establishment of works for the production of Portland cement, for which, should suitable clays be found, this chalk will supply the other ingredient.

From a geological point of view, the discovery of this chalk is also interesting, not less so than it is practically to the immediate district in which it is found. As forming the last member of the Cretaceo-Tertiary rocks exposed here, the presence of this chalk as an equivalent of the Amuri limestone renders this section intermediate between the sections of the same series exposed in the eastern part of the Malvern Hills and Middle Waipara Districts. In the Malvern Hills the section closes with rocks wholly dissimilar to the chalks which here form the last of the Cretaceo-Tertiary series. The loose sands underlying the volcanic rocks of the Harper Hills it may be allowable to regard as the horizontal equivalents of the Amuri limestones, or of even yet higher beds; but it is equally possible to maintain with no inconsiderable show of reason that they belong to a lower horizon.* Sufficient be it to say that no chalk, nor higher rocks of that series, are there seen. Here the chalk or Amuri limestone is present, while in the Waipara section two additional members of the series are present, the last of which forms the highest yet known.

As far as yet known, neither in the Malvern Hills nor on the banks of the Eyre River are fossiliferous beds associated with the volcanic rocks in such a manner as to lead to a determination of their precise age, which therefore has to be settled by analogy and inference. A considerable array of facts has elsewhere been given bearing on this point, of which but little doubt can remain.

* The rapid change in the character of the chalk, when followed to the westward, may favour the first alternative here put, which will better agree with my interpretation of the Curiosity Shop section. *Vide post.*

Before closing this report it will be necessary to say something as to the character of the beds which, belonging to the same series, are found underlying the chalk. The creek already mentioned as coming from the north-west, and joining the Eyre at Ingram and White's saw-mill, on passing the north-eastern termination of the chalk ridge runs for some distance through thickly-bushed country along its north-western base. Greensands are exposed in the bed, and form the banks of this creek, which pass into sands of a lighter colour as the section is followed upwards towards the chalk. These sands, it cannot be doubted, are the equivalents of those overlying the coal measures in the Malvern Hills. Further to the north and west a thickly-bushed flat or undulating track of country lies between the chalk ridge and the south-eastern slopes of Mount Oxford. To the north-east this track of low country is bounded by ridges of moderate height, but full of broken ground, and densely covered with bush. Here, however, it is apparent that a change in the nature of the rocks present takes place, as on the north-eastern side the country is rough and rocky, and not everywhere covered by bush. In the open patches the rocks belong to the red and green diabases and cherts of the Malvern Hills.

North-west of the ridge in which the chalk occurs there is every reason to believe that coal seams may yet be found, between there and the foot of the Mount Oxford Range. Professor Von Haast, in his late work on the geology of Canterbury and Westland, shows on the map accompanying that report as present Middle Tertiary rocks in this locality, which must be those here alluded to. Nevertheless, in consequence of the evidence afforded by the chalk, the conformity in the character of the greensands here to those in the Malvern Hills, and the evidence of the occurrence of *Conchothyra parasitica* in the district, I could not decide otherwise than that such rocks must be of the same age as the coal-bearing strata in the Malvern Hills.

OF THE TRELISSIC BASIN, SELWYN COUNTY.

REPORT BY ALEXANDER M'KAY.

Introductory Remarks.

This most instructive locality, although it has been frequently visited and partially examined by geologists, and has been very exhaustively studied and collected from by Mr. J. D. Enys, F.G.S., on whose property it is situated, has never yet been described in the detailed manner it deserves. Considering the deep interest taken by Professor Von Haast in all matters relating to the geology of Canterbury, it is somewhat surprising that, in his recent work, he has given no special account of this singular detached basin, within which the whole series of Cretaceous and Tertiary rocks are developed. This is more inexplicable as typical sections have been selected by Dr. Von Haast from other localities which are not only comparatively barren of fossils, but also imperfect in the sequence which they are intended to illustrate.

A single instance may be given bearing on this: The section along the south bank of the Ashburton, between the Brothers and the Limestone Bluff, is detailed bed by bed as a typical section of the "Oamaru formation" of that work, while only three species of fossils are mentioned as identified in the rocks of the same sections.* As a contrast with this, it may be stated that within the same range of section, bounded so as to agree with the nomenclature of Professor Von Haast's classification, at least 200 species of fossils have been collected from the rocks of the Trelissic Basin.

With far better excuse on his side, as forming part of a progress report on a very extensive district, Professor Hutton, in his "Report on the North-east District of the South Island," dismissed the rocks of the Trelissic Basin almost without remark; but his descriptions of the ample collections of fossils which had been made in this locality by Mr. Enys and Dr. Hector have proved of great assistance in the detailed study of the district. Dr. Hector's collections were made in December, 1872, and he at the same time made the geological map and sections, showing the structure of the Trelissic Basin, which are used to illustrate the present report.

The history of what has been done to illustrate the geology of the Trelissic Basin would be wanting in some of its most important details, did I overlook the labours of J. D. Enys, Esq., in bringing together the splendid collections from all parts of the basin which he has done. As owner of Castle Hill Station and a resident in the district, he has had opportunities which, to say the least of them, have not been neglected: of which there are in both the Colonial and Canterbury Museums splendid memorials, without which our lists of Lower Tertiary fossils would be far less ample than they are.

THE TRELISSIC BASIN.

From Canterbury Plains, in the vicinity of Christchurch, the view westward is backed by a series of rugged mountains. These stretch from the point where the Waimakariri first touches the Canterbury Plains to the Rakaia Gorge. Their highest peak is Mount Torlesse, situate in the north-east end of the chain, rising above the sea-level to a height of 6,434 feet, while the Thirteen-Mile Bush Range and Big Ben are about 5,000 feet. Together, these ranges seem to bar all progress westward, except by turning their flanks at either termination; yet across the central portion

* "Geology of Canterbury and Westland," p. 307.

of this block of mountains lies the road to the Trelissic Basin and the west coast of the Island.

Advancing westward till the Malvern Hills are passed, we enter the valley of the Kowhai River, which, with a width of nearly a mile, is continued to the junction of the stream flowing north-east from the Big Ben Range. The valley of the Kowhai now narrows considerably, but for a short distance again. expands at the foot of Porter's Pass. Here the river, leaving the road-line, trends away to the north, and rises in the higher parts of Mount Torlesse.

The pass itself not being observable from the approach thereto, it seems as though the road had been taken across the range at the nearest point, regardless of any pass whatever. Following the road along a steep gradient round a projecting spur, the pass is at length revealed, and crossed at a height of 3,097 feet. This gained, and the steeper gradient in the immediate vicinity of the saddle descended, a narrow valley leads down to Lake Lyndon, an oblong sheet of water filling the upper part of a longitudinal valley lying at the western foot of the range, from the western shore of which the mountains in that direction rise abruptly.

Although at an elevation of 2,740 feet above the sea, and lodged, without level land on either side, between two high mountain-ranges, Lake Lyndon has no imposing features about it, and can hardly be said to be more than picturesque. The chief feature of interest in its surroundings lies in the immense dam of *débris* by which to the northward its waters are held back from escaping in that direction. Strictly speaking, Lake Lyndon lies to the northward of the true saddle, while its surplus surface-waters escape to the south, the shingle saddle intervening between its northern end and the springs feeding the Porter River in reality only choking the valley which to the northward leads into the Trelissic Basin. This great shingle-fan is due to the friable character of the rocks which form the western spurs of the Mount Torlesse Range. These, readily breaking up into shingle, are rushed down the steep slope of the mountain during heavy rains till they reach the base of the mountain, and are lodged there; while the stream which at one time flowed to the north, getting continually choked, and unable to reinstate itself in its original course, gradually accumulated behind the barrier as a lake, and eventually found escape in the opposite direction.

Passing over this great accumulation of shingle, and following the road to the northward, the spurs bounding the valley on the left hand terminate near the springs feeding into, and with Coleridge Creek forming, the Porter River. We have now entered the Trelissic Basin. The Trelissic Basin is obtusely triangular in outline, the space enclosed by the surrounding mountains being about 8 miles in length, from north to south, by about 3 miles in width in the widest part. The average elevation of the central level ground within the basin is 2,300 feet. Mountains exceeding 5,000 feet in height surround the basin on all sides except to the north-east, in which direction they are somewhat less. At the northern end lies the Craigieburn Saddle, by which the West Coast Road leads down to Lake Pearson and the Waimakariri Valley. In the central-eastern part of the surrounding rim of mountains is situate the gorge of the Broken River, by which the drainage of the basin escapes to join the Waimakariri. To the south is the Lake Lyndon Saddle, leading to Porter's Pass and down the valley of the Acheron River to the Rakaia.

Except these and a high mountain pass situate at the source of Coleridge Creek, which in a south-west direction leads into the Rakaia watershed, there are no other means of reaching the Trelissic Basin. The Coleridge Creek Pass and the gorge of the Broken River are never used as means of entering the basin, except by residents well acquainted with both. The area thus enclosed by a framework of high mountains is not level throughout. The flat grounds are situate in the middle space, and surrounded by a rim of lesser hills, having generally a depression as a narrow valley between them and the higher mountains. These hills present steep scarps outwards towards the mountains, while towards the middle part of the basin the slope is not so abrupt. In the north-western corner these lower hills form two or more parallel ridges before the slopes of the high range are reached, while on the east side and in the southern end of the basin they are single.

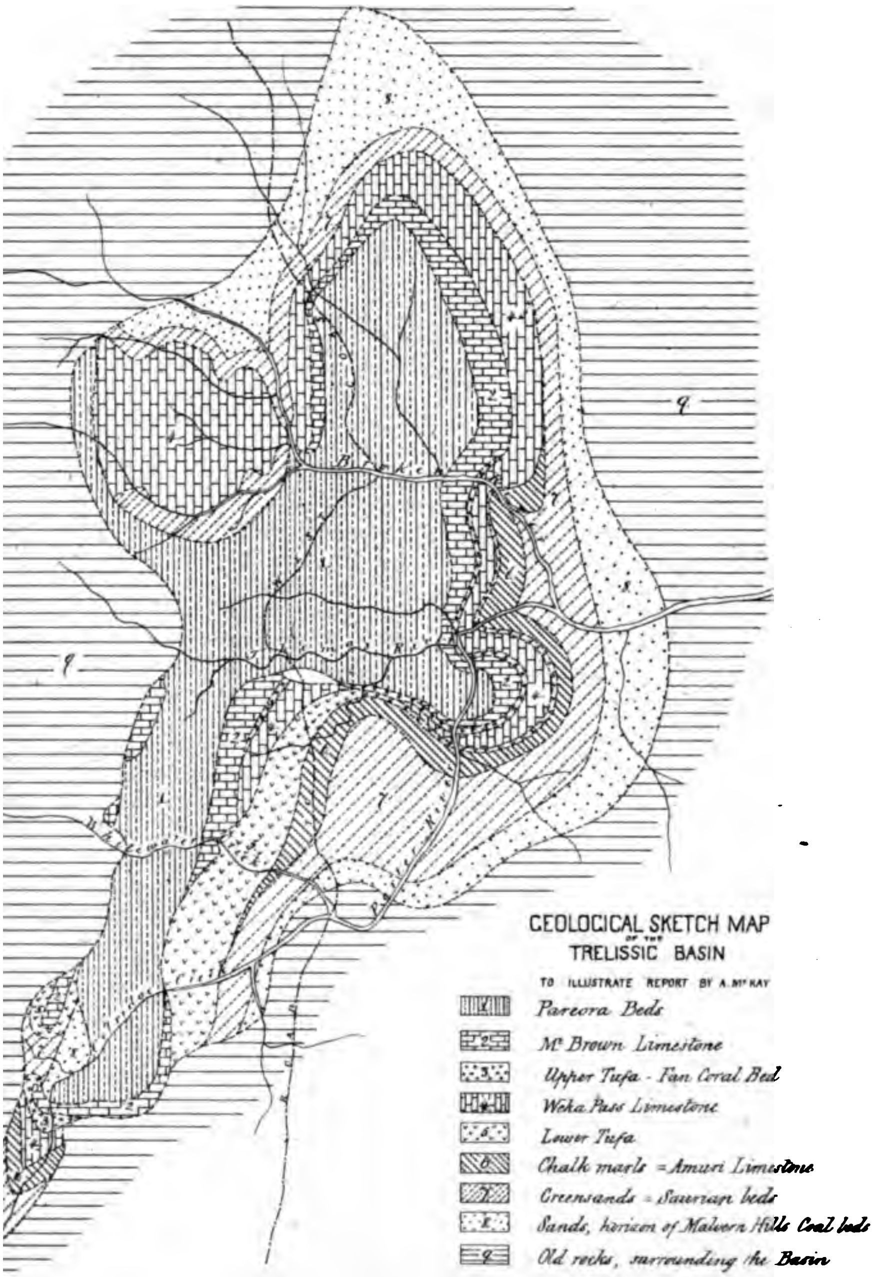
The Porter River, a stream but a few yards in width and easily fordable on foot when not in flood, drains the southern end of the basin. It draws a large and constant supply of water from the springs situate at the point where the valley leading north from Lake Lyndon enters the Trelissic Basin, the water thus supplied appearing to be drainage through the shingle-fan from the lake.

These springs, forming a considerable stream, are a little to the north joined by Coleridge Creek, a small mountain stream rising to the south-west, flowing in the first part of its course through a deep, narrow valley bounded by older rocks, and in the latter part of its course confined between steep terrace scarps which it has formed in cutting through the softer rocks within the basin itself.

The united waters of these two streams flow east-north-east along the western base of the Mount Torlesse Range, and, where crossed by the road to the West Coast, are joined by Whitewater Creek coming from the westward, which, cutting deeply through the shingle deposits and younger rock, makes its appearance within the basin from a deep gorge between two spurs of the range in which it takes its rise. A triangular hilly space of no great extent, with a shallow depression between this and the adjoining range, separates the lower parts of this and Coleridge Creek.

Geological Survey of New Zealand.

JAMES HECTOR, C.M.G., F.R.S., DIRECTOR.



A short distance below the junction with Whitewater Creek the Porter River turns a point or so to the north to avoid a rounded sloping spur coming from Mount Torlesse Range, which bars its straight course in that direction. The river now runs along the base of a high terrace on its western bank till it reaches the first limestone gorge at the western end of Ram Hill, where, breaking through some thick beds of limestone rock, a distance little more than a quarter of a mile brings it tô the second gorge and the junction of the Thomas River. This small stream, rising north-west of the central part of the basin, cuts, on entering the softer rocks, a deep narrow valley directly across the basin to the point where it joins the Porter at the second limestone gorge. Reaching the Porter River through a narrow gut or gorge, the Thomas River makes a junction with the larger stream before breaking through the limestone for the last time, which passed, the river flows between high banks half-a-mile to its junction with the Broken River.

This, considerably the more important stream, takes its rise in the mountains to the north-west, and is formed by the union of several mountain streams within the limits of the lower area covered by the younger rocks. Being a stream of greater volume than the united Porter and Thomas Rivers, it has cut a yet deeper but still a narrow valley through the soft rocks filling the central part of the basin, and, by a deep, narrow gorge, breaks through the eastern rim of limestone hills. Before entering the limestone gorge the Broken River receives from the north a small stream which, rising near the Craigieburn Saddle, has almost its whole course within the younger rocks of the basin. This creek, quite disproportionate in volume to the length of its course, which is in a south-south-east direction, cuts a deep valley through the softer rocks, and, at Parapet Rock, has broken through the harder limestone as well. On passing through the limestone gorge the Broken River flows south-east to the point where it is joined by the Porter River, where, turning more to the east, within a distance less than a mile it plunges into a deep gorge, and is in its further course beyond the limits of the Trelissic Basin.

After having studied the effects of glacier-action in the mountain regions of the South Island, and seen how potent has been, and still is, the great "ice-plough," if we, as reasonably we may, assume that the valleys of our great rivers have not merely been polished by ice, but actually in great part owe their very existence to its action, no great surprise need be engendered by a first and cursory glance at the physical conditions of the Trelissic Basin. We might simply conclude that it has been excavated by ice, and that this, in the form of glaciers, was quite competent to do all the grinding, scooping, and carrying-forward necessary to accomplish the work. To the south, we might say, the Mount Torlesse Range, before the glaciers, to their own diminishment, had cut into its plateau-like top, supported vast accumulations of snow, from which snow-fields great glaciers descended to the north. From the west and north the mountains yielded as great and even larger glaciers, all of which converged to a point where now are situate the lower grounds of the Trelissic Basin. Aided by the friable nature of the rocks forming the mountains, and by a strange coincidence in the presence of younger and softer rocks near the point of convergence, the glaciers rapidly performed their work, but at the same time gradually cut off their source of supply, and, diminishing in volume and power, were unable to remove their carried material outside the basin excavated, which was in this manner partially filled by huge accumulations of shingle and other *débris*.

We might further speculate that the glaciers still clung to the mountain-sides, but were unable to reach the lower grounds which they had formerly excavated, now filled by the waters of a lake. This lake indicated clearly the outlines of the basin, and its waters were held back by a high ridge now cut through by the gorge of the Broken River at the eastern obtuse corner of the basin. Ram Hill and the limestone hill between the Porter and the Broken River were now islands in this lake, while the limestone range further to the north beyond the Broken River formed part of its eastern shore. Reclamation commenced at the infall of the various streams, and the high-level terraces of which remnants are still left were formed. The terrace extending from behind Mr. Enys' home station to the several source branches of the Broken River was formed during this period, and may be considered the best remaining example. But meanwhile the barrier at the outlet was being rapidly denuded, the lake lowered, and again terraces formed at lower levels. The lake being now considerably less in depth, the material carried into it by the streams filled it up rapidly, and, at the same time the outlet being further lowered, its bed was at length laid dry.

The two principal streams—the Broken River in the north and the Porter River in the south—now flowed as shallow water-courses across the bed of the former lake in the direction of the outlet in the eastern corner; and, each making as direct a course as circumstances would permit, junction with each other was not effected till they had passed the rim of limestone hills already mentioned as occupying the east and north-eastern sides of the basin. The isolated hill which stood as an island in the now drained lake afforded an outlet between it and the range to the north for the Broken River, while between it and Ram Hill the Porter River escaped by its present gorge, but in both cases at levels higher by some 200 feet than their present beds at the same point.

As the united river cut into the rocks and lowered its bed eastward of the line of limestone hills, so the Porter and the

Broken Rivers gradually cut through the limestone rocks, and, settling into definite channels, excavated the deep narrow valleys in which their waters now find their way across the basin. This in some measure effected, the lesser streams in like manner commenced the same process, which is yet in progress at the present hour.

Were it necessary we might, with Professor Von Haast, suppose that long after they had deserted the lower lands within the Trelissic Basin glaciers of considerable size yet lingered in the narrow valleys near the sources of the principal streams, the moraine of one of these forming the dam which now holds back Lake Lyndon.

In the manner thus sketched in the foregoing speculation the surface features of the Trelissic Basin might have been formed, and thus no doubt to a slight extent they have been modified; but it does not follow that this curious depression had an origin wholly due to these causes. On the contrary, the geological structure of the younger beds within the basin gives ample proof that movements of the strata forming the surrounding mountains have had much to do with its original formation, however much it has been deepened or modified by other agents acting subsequently. Moreover, the evidence of the rocks is decidedly against the theory that glaciers have to any material extent had an influence in shaping the lower grounds of the basin.

Within the Trelissic Basin are included all the marine Tertiary rocks known to occur in Canterbury except the littoral and estuarine beds, which, as coarse gravels, close the Pareora formation. These higher beds probably never existed within the Trelissic Basin. The highest beds of the Pareora formation, as brown and grey sands underlaid by greenish sandy clays, are yet preserved, and are developed to a considerable extent and exposed in situations where they must have suffered the full denuding force of one of the largest of these hypothetical glaciers, did it ever reach thus far. These soft sandy beds have an exposure of nearly a mile and a half in the central part of the basin, and the highest beds are yet preserved in the western part of the section.

All the younger strata on the eastern side dip inward: on the western side folding in an irregular manner has taken place, but the dip is, where not necessarily otherwise, towards the centre of the basin also. This disposition of the strata, together with the fact that the younger formation has not been seriously denuded of its higher beds, shows that the basin as such is the result of movements accompanying the elevation of the surrounding mountains, since which time it has not altered greatly in outline, nor been deepened to any extent by excavation.

No doubt at one time a lake was formed, which was filled and its bed excavated much in the manner already described; but there is little—in fact, no—evidence that the supposititious glaciers ever existed, no strictly morainic accumulations being found within the basin. Yet, considering that this in its central part is 2,300 feet above sea-level, and surrounded by mountains between 6,000 and 7,000 feet in height, evidences of the presence of glaciers would not be surprising when we consider that during the same period the valleys of the Rakaia and Waimakariri were filled with ice.

FORMATIONS.

Not including superficial deposits, the following table includes all the rocks found within the Trelissic Basin, as classified in Dr. Hector's map and sections:—

Table of Formations.

Age.	Formation.	Character of Strata.
IV. Lower Miocene	1. Pareora formation ...	Principally loose sandy beds, with shell beds and bands of shelly sandstone.
V. Upper Eocene	2. Mount Brown limestone	A shelly and coralline limestone.
	3. Hutchinson's Quarry beds (fan-coral bed)	Volcanic tufa and agglomerate, with abundance of marine shells.
VI. Cretaceo-Tertiary	4. Ototara limestone ...	Close-grained calcareous sandstone.
	5. Lower tufa	Intensely dark fine-grained and rubbly tufas.
	6. Chalk-marls	Chalk-marls, representing the Amuri limestone.
	7. Concretionary greensands	Bright-coloured greensands, with concretions.
	8. Boulder-sands ...	Sands overlying the coal, with large concretions.
	9. Black grit and coal ...	Black oyster-bed, sandstone, grey sands, shale, coal, &c.

FORMATION VI.—CRETACEO-TERTIARY.

The Cretaceo-Tertiary rocks may for convenience be divided into two groups: the greensands, boulder-sands, and lower beds in the lower; while the Ototara limestone, lower tufas, and chalk-marls form the upper group.

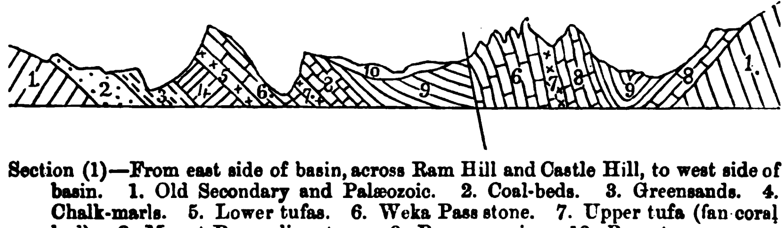
Lower Group (Nos. 7, 8, 9, of Map).

This lower division of the Cretaceo-Tertiary rocks are first seen in the southern end of the basin in the lower part of Coleridge Creek. There they are exposed in the banks of the creek, only superficial beds interfering greatly with their clear exposure. Continued eastward they again show in Whitewater Creek near its junction with the Porter River, and, though badly exposed, the sequence appears more complete than in Coleridge Creek. Sandstones, grey sands, and shaly coaly beds form the lowest beds, dipping to the westward at considerable angles, and rest on the older slates, &c., belonging to the rocks of the Mount Torlesse Range, while higher up the creek chalk-marls are exposed in the bed of the stream. The strike of these beds is to the north-east. In this direction they pass under the gravels of a considerable flat which between Whitewater Creek and the Thomas River lies to the east of Castle Hill, between that and Mr. Enys' woolshed, where, hidden by the overlying deposits forming this flat, the Cretaceo-Tertiary rocks turn sharply to the eastward, and strike across the Porter River above the first limestone gorge. At this point the banks of the river expose fine sections of the greensands, and the same rocks are well exposed on the ridge connecting Ram Hill with the lower slopes of Mount Torlesse. From this point the lowest beds of the series make a wide sweep to the east and north, crossing Broken River, and passing between the limestone ridge and the mountain range bounding the Trelissic Basin to the north-east. While thus the lower beds sweep round with a uniform curve, the higher beds immediately under the chalk-marls accommodate themselves to all the vagaries of the overlying calcareous part of the series. Reaching along the eastern border of the basin to within a short distance of the Craigieburn Saddle, the lower beds turn sharply to the west, and in doing so show a greater breadth of exposure than usual. The beds now strike to the south-west, and north of the Parapet Rock form a swampy valley, by which the road approaches the Cragieburn Saddle.

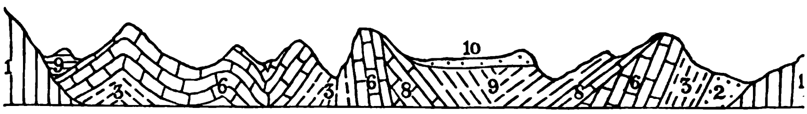
From Parapet Rock and the ridge to the north-west the beds crop out with a generally western trend of the lower members; but the higher beds follow the sinuations of a number of irregular anticlinal folds, which are in some raised at the south end of the syncline, in others at the north end, so that the line followed by any one particular bed is tortuous in the extreme; and the presence or absence at the surface of the lower rocks depends upon the manner in which the overlying strata have been folded and afterwards denuded.

The peculiarities of the strata occupying this corner of the basin will be more fully described in giving an account of the higher limestone rocks of this and the series next succeeding.

The best-known section of this lower portion of the Cretaceo-Tertiary series is thus shown in Sections (1) and (2), exposed in the banks of the Broken and Porter Rivers east of the limestone ridge striking north from Ram Hill :—



Section (1)—From east side of basin, across Ram Hill and Castle Hill, to west side of basin. 1. Old Secondary and Palæozoic. 2. Coal-beds. 3. Greensands. 4. Chalk-marls. 5. Lower tufas. 6. Weka Pass stone. 7. Upper tufa (fan coral bed). 8. Mount Brown limestone. 9. Pareora series. 10. Recent.



Section (2)—From Hog Back, along north side of Broken River. 1. Older Secondary or Palæozoic. 2. Coal-beds. 3. Greensands. 6. Weka Pass stone. 8. Mount Brown limestone. 9. Pareora beds. 10. Recent.

The lower beds are grey sands, such as usually accompany the coal in the Malvern Hills and in the Waipara sections. Overlying these are beds of sandstone of a more calcareous character (glance sandstone), which in places contain fossils. From these beds I collected in 1877 a variety of fossils, amongst which were *Conchothyra parasitica* (McCoy), the well-known fossil of the coal measures in the Malvern Hills, found also in the Middle Waipara and at Amuri Bluff. With this shell there occurred a *Perna* of which good specimens were obtained, a highly ornamented *Cerithium*, and some others. Sands yet succeeding these are closed by a bed of fossiliferous rock, in which the principal shell is an oyster resembling, if not identical with, the black oyster of the Waipara and Malvern Hills. The specimens to be obtained are generally not as large as those from the latter localities, but are much the same in character. Near Craigieburn Saddle, where the lower beds are of a shaly character, dicotyledonous plants and ferns occur. Above these beds in the Porter River, below the limestone gorge, bright-coloured greensands having a considerable thickness are exposed. These are not, as far as I know, fossiliferous in this section, but on the southern side of Ram Hill some of the creeks cutting through these greensands have small concretionary boulders of glance sandstone, which contain fucoid stems and fossil shells. Of the latter the only form identified is a *Tellina*. From the same greensands, where they cross the Porter above the first limestone gorge, Dr. Hector's collection contains *Ostrea subdentata* (Hutton), which also occurs in the overlying chalk-marls, and is of frequent occurrence in the Cobden limestone at Greymouth, on the West Coast. On this occasion these beds were not particularly examined, and no collections were made there, from attention being more particularly directed to the higher beds from the chalk-marls upwards.

Upper Group (Nos. 4, 5, 6, of Map).

Chalk-marls (6) representing the Amuri limestone are principally developed on the central-eastern side of the basin. Beginning from the south they are first seen well developed in the bed of Whitewater Creek, striking in a nearly north-and-south direction. They must be continued in this direction till they come within a few chains of the south bank of the Thomas River, having in this part of their course a high westerly dip. From this point they are sharply bent back to the eastward, and make their appearance in the banks of the Porter River above the first limestone gorge. At this point they are strongly developed and well exposed, having a thickness of from 100 to 150 feet. In Whitewater Creek they are little else than a light-coloured clay-marl; but here they are highly calcareous, and fully merit the term "chalk-marls."

On the opposite bank of the river, in the abrupt scarp of Ram Hill, these chalk-marls are crowded with large and beautiful impressions of fucoids, having the radiate and reticulate structure which distinguishes the same fossil at the Amuri Bluff and at Greymouth. These fossils have no traces of carbon left, but simply show as casts in the partings of the chalk-marls. Round the south-east and north-east sides of Ram Hill these chalk-marls are traceable till they again cross the Porter River, where in section they are again well displayed. They are further continued to the north-east along the eastern scarp of the limestone range, but appear to thin out as they are followed in this direction, and are but feebly represented in the northern part of the basin.

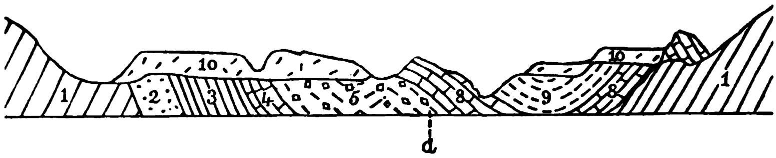
At Parapet Rock they are not represented, the Ototara or Weka Pass limestone there resting on the underlying sands.

Except *Ostrea subdentata, Pecten pleuronectes*, fish scales, and a few Foraminifera, no fossils other than the fucoid markings have been found in these chalk-marls. Stratigraphically their position is clear, and there can be no doubt that they represent the horizon of the Upper Chalk and the Amuri limestone.

The next succeeding beds (5), though constant in character, are local in development, and in the main confined to the southern part of the basin. They consist of volcanic ejectamenta, varying in grain from coarse rubbly material to a fine-grained tufa. The material is wholly of a basic character, producing strata of a dark-green or black colour. There is a heavy development of these beds in that part of Coleridge Creek lying above the point where the saurian beds cross to the southern bank. Stratigraphically at this point they are more important than elsewhere, but, not being fossiliferous, in this respect the beds here are of less interest than in Whitewater Creek, or at the first limestone gorge in the Porter River. In Coleridge Creek these tufas close the Cretaceo-Tertiary series, being on the left bank of the creek overlaid by the Pareora beds, of which the junction is clearly seen, while on the south bank of the creek the Mount Brown limestone is present as the lowest bed of the overlying series.

In Whitewater Creek these volcanic tufas—5 in Section (3)*—have a thickness probably less than they show in Coleridge Creek; but, their angle of dip being less, they show a breadth of exposure quite equal if not greater. In this section their upper beds become calcareous, and are full of fossils, which occur in great variety, and usually well. Where next seen, at the upper limestone gorge in

* *See* page 64.



Section (3)—From Porter River along south bank of Whitewater Creek. 1. Old Secondary or Palæozoic. 2. Coal and greensand beds. 3. Greensands. 4. Chalk-marls=Amuri limestone. 5. Breccia and tufa beds. (*a*) Fossils. 8. Mount Brown limestone. 9. Pareora beds. 10. Recent and Pleistocene.

the Porter River, these beds have thinned to a few feet in thickness, and on following round the outward scarp of Ram Hill are obscured between the Porter and Broken Rivers, and not known farther to the north. Not having examined the eastern slopes of the limestone range north of the Broken River, it may be that this horizon is traceable as a distinct parting between the chalk-marls and the overlying Weka Pass stone as far as the former reach in that direction. There is no evidence of the tufas being present under the Weka Pass stone at Parapet Rock.

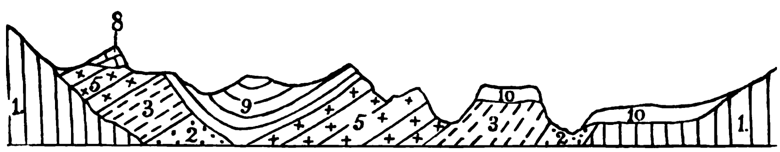
There is between this series of tufaceous beds so much resemblance to another thick bed of the same material interposed between the Weka Pass and Mount Brown limestones, that, except both be seen in direct sequence, it is hard to be convinced that they are not one and the same. In Whitewater Creek both these limestones are not present, and that which is I regard as being the Mount Brown limestone. At the time when I made the collection from the tufa beds in Whitewater Creek, I was inclined to believe that it belonged to the horizon underlying the Weka Pass stone, and did not represent the upper tufa bed at the junction of the Thomas River with the Porter. The Weka Pass limestone being absent, it could not then be definitely determined which horizon was represented, even although a considerable difference was remarked in the fossils of the two localities. Arguing, however, that the Weka Pass stone had been removed by denudation, the upper tufaceous beds must have been swept away in this operation, unless this higher tufaceous bed belonged to the succeeding unconformable series, a question which only can be settled by a strict comparison of the fossils obtained from the two localities. The fossils collected from these beds at the first limestone gorge on the Porter River were too few to serve the purposes of this comparison; yet, as far as these may, they tend to show that those from Whitewater Creek belong to the lower tufas at present under consideration. The comparative list at the end of this report will show upon what grounds this opinion rests. Whichever way this matter is decided, it still remains that *Pecten hutchinsoni* and some other forms must be considered to range beyond the limits of our Upper Eocene rocks, as they come from the tufas underlying the Weka

Pass stone at the first limestone gorge of the Porter River. At the same time, while present in the upper beds at the junction of the Thomas River, many forms are not found at Whitewater Creek, or in the tufas which are overlaid by the Weka Pass stone.

Ototara Limestone.

This rock (4), which is here spoken of as the Weka Pass stone, is a calcareous sandstone of good quality, which, largely developed in Castle Hill, supplies there an excellent building stone. The thickness of this stone varies from 50 feet to more than 100 feet in different localities, Castle Hill, on the west side of the basin, between the Thomas River and Whitewater Creek, showing perhaps as great a development of this rock as is to be seen within the basin. Comparatively few fossils have been obtained from this rock, but, with the overlying Mount Brown limestone, it forms the most prominent feature within the Trelissic Basin. These together show better than any other rocks the general structure of the younger rocks within the basin, as they stand prominently above the general level of the surface, and by their dip and recurrence on the opposite sides of anticlines and synclines indicate the presence or absence of particular rocks which at many points cannot clearly be seen. Although belonging to different formations, and not at all times present in a given line of section, it will be advisable to trace the outcrops of these rocks as one, and thereby save a considerable amount of repetition, as otherwise much of the same ground would have to be gone over a second time.

Beginning again in the southern end of the basin, limestones are first seen resting upon the lower tufas (numbered 5) in Coleridge Creek, as shown in Section (4).



Section (4)—From east side of Porter River along the north bank of Coleridge Creek. 1. Old Secondary and Palæozoic. 2. Coal-beds. 3. Saurian and greensand beds. 5. Lower tufa. 8. Mount Brown limestone. 9. Pareora beds. 10. Recent.

These run some distance up the narrow valley of this stream, and there may be said to be outside the basin proper. Both the Weka Pass and Mount Brown beds appear to be at present separated by the upper tufa beds.

Where the creek valley widens and merges into the south-west corner of the basin the Mount Brown limestone alone appears, as is the case a little further to the eastward, on the spur behind the Stone Hut. At this last place the limestone suddenly turns to the north, showing a westerly dip, and for the time terminates on the south bank of Coleridge Creek. In the same line of strike it reappears on the south side of Whitewater Creek, and strikes northerly to the crossing of the Thomas River, opposite Castle Hill Hotel.

Between Whitewater Creek and this point the limestones form a range of hills 300 feet or so above the lower-level terrace-land, and weather into fantastic shapes: hence the name Castle Hill. Reaching quite to the brow of the terrace overlooking the Thomas River, the limestone alters its strike by a greater degree than a right angle, and now, striking eastward, crosses the Porter River at the western end of Ram Hill. In Ram Hill the limestone outcrop forms quite half a circle within a radius the diameter of which is not more than half a mile, and again crosses the Porter River at the lower limestone gorge, near the junction of the Thomas River with the Porter. It now strikes north to the Broken River, north of which the limestone is set back to the east, apparently by a fault in the line of the Broken River. North of this it is continued as a rocky limestone range to within three-quarters of a mile of Craigieburn Saddle.

As far as hitherto traced the dip has been to the west or north, except at the northern end of Ram Hill, where for a short distance it is nearly in a south direction.

Having reached the northern point of its extension along the east side of the basin, the limestone forms a syncline, raised so as to show the beds round its northern end, rapidly widening to the south: in fact, the limestones now strike south-west to Parapet Rock, and thence more to the west across the north branch of the Broken River. On the west bank of this stream the limestone again turns to the north. It trends but a short distance in this direction, when it again turns as sharply to the south, producing a narrow syncline, with an anticline to the west of it. This syncline appears closed to the north by the limestone running round that end of it.

At the southern end of the anticline—the furthest to the west yet described—the limestone does not cross the south branch of the Broken River, but, turning sharply first to the west and then to the north, forms an abrupt ridge of limestone running along the north-west side of the basin, and known by the name of the Hog's Back.

Between the Broken River and the Thomas River no limestones are known to occur on the western side of the basin. The country in this direction is covered with bush, and but imperfectly explored geologically.

On the south side of the Thomas River, along the west side of the basin, the limestones form a syncline, carrying younger rocks between, and on the north side of Whitewater Creek a small outlier of limestone rock, dipping west, appears on the side of the range. Along the side of the range, between this last outcrop and

Coleridge Creek, limestone appears in one or two places as small patches isolated from the main line, and not showing definitely how they are related to the main outcrops.

I have now traced the limestone wherever it is to be seen cropping out within the basin, and, having already spoken of the Weka Pass stone, shall proceed to a consideration of the next overlying beds.

FORMATION V.—UPPER EOCENE.

Upper Tufa (No. 3 of Map).

In the northern part of the South Island the Weka Pass and Mount Brown limestones are separated by the grey marls, forming the highest division of the Cretaceo-Tertiary series. These thin out rapidly as they are followed to the south, and are not known to be represented in Canterbury south of the Grey Stream, a branch of the Okuku River coming from the southern slopes of Mount Grey.

To the southward lava flöes and breccia tufaceous beds occupy the position of the grey marls between the beforementioned limestones, and, being closely related to the higher of these, are considered to be unconformable to the grey marls, or would be so were such present in the same section.

The close relationship of these tufaceous beds to the Mount Brown limestones and the base of the Tertiary series has been discussed in a report on the Curiosity Shop beds; and, not doubting that the beds now to be spoken of belong to the same period, they are here taken as marking the lowest Tertiary horizon in the Trelissic Basin. They are best seen on the left bank of the Porter River, between the first limestone gorge and the junction of the Thomas River with the Porter, and are further traceable between the two limestones some distance in the direction of the Broken River. The beds in character much resemble the greater development of tufas in Whitewater and Coleridge Creeks, but are not more than 30 feet in thickness. The bed is finely exposed at the junction of the Thomas River, where, from the abundance of a particular fossil, it has been called the "Fan-Coral Bed." At this place a great variety of fossils have been collected by Mr. Enys and others, and here a good collection was also made on the present occasion.

The upper surface of this bed passes insensibly into the Mount Brown limestone in places. At other points the change is more marked, the limestone succeeding suddenly, but the character of the collection is not in any degree affected by such changes.

The relation of this fan-coral bed to the underlying Weka Pass stone is different, and marked at the upper limestone gorge of the Porter River by a decided unconformity. At the same place the tufas are seen to underlie the Mount Brown limestone conformably.

North of the central part of the basin this bed has not been traced; but in the south-west corner, where the Mount Brown limestone occurs at the edge of the basin in Coleridge Creek, the tufas are seen both to underlie and to be interbedded with that limestone. It is from the softer calcareous tufas between the limestone at this place that the principal collections of fossil teeth have been made. These and other fossils from the same bed may with propriety be regarded as belonging to the Mount Brown limestone.

Mount Brown Limestone (*No.* 2 *of Map*).

This division of the Upper Eocene rocks is 20 feet to 30 feet in thickness. Sometimes it is harder, but generally it is softer than the Weka Pass stone, and differs in being chiefly composed of small corallines, the Weka Pass stone not showing this structure to the same extent. The outcrops of this have been traced along with those of the Weka Pass limestone, the two being generally present in the same line of section. This rock is richly fossiliferous at both its under and upper surfaces, but except in small corals it is not so in its middle part save in Coleridge Creek, where by the interposition of tufa beds it loses its ordinary character.

The upper surface of this rock marks an unconformity which separates the Upper Eocene from the Lower Miocene rocks, which are the next overlying. Elsewhere on the east coast of the South Island this unconformity is not well marked, and the Pareora beds usually succeed with only a change in the lithological character of the strata. Here however there is an eroded surface where the rock has not been wholly removed, and on this surface boring molluscs of the Miocene seas have penetrated the Eocene limestone, and bored not only the larger Eocene fossil shells, but also the consolidated matrix which filled and surrounded them. That a very considerable amount of denudation affected the rocks of the Trelissic Basin has, by other evidence, already been shown, as, for instance, where it is stated that the Pareora beds in Coleridge Creek rest directly upon the tufas below the Weka Pass stone; but in that case the denudation may have taken place prior to the deposition of either the Mount Brown beds or the underlying upper tufas, as shown by the unconformable relations of these latter to the Weka Pass stone. From this it appears that the amount of denudation in the latter case need not have been great, nor does it appear to be so except at one or two points.

FORMATION IV.—LOWER MIOCENE ROCKS.

Pareora Formation (*No.* 1 *of Map*).

In the southern end of the Trelissic Basin these rocks are found filling a syncline formed by the limestone rocks along its western side, which, beginning on the banks of Coleridge Creek, is continued north as a narrow strip, passing behind Castle Hill Range to the Thomas River above the crossing of the West Coast Road. Here the beds expand in the breadth of their exposure, and in the central part of the basin between the Thomas and the Broken River reach to the foot of the high ranges bounding the basin to the north-west.

In this part of the basin these younger beds necessarily abut against or rest highly unconformably upon the Lower Cretaceo-Tertiary rocks. On the eastern side of the basin their relations, as already pointed out, are of a more conformable character. North of the Broken River the breadth of their exposure is again much contracted on account of the trend of the limestones in that direction; and north and east of Parapet Rock they are confined to the syncline between the limestone outcrops. West of the Hog's Back a small outlier of these rocks rests against the slopes of the higher ranges in that direction. This latter patch of these beds was discovered by Mr. Enys since I visited the locality.

In the central part of the basin there is a considerable thickness of strata belonging to this formation—probably not less than 400 feet. The lowest beds are loose grey or yellow sands, with shelly bands more or less consolidated. These are overlaid by a considerable thickness of grey sands, with thin beds of shells which lie loose in the sands. Overlying these latter are bands of grey sandstone full of shells, associated with thick banks of shells in a matrix less consolidated. This is the principal horizon for the collection of fossils from this formation in the Trelissic Basin.

Thirty to fifty feet overlying these shell-beds the sands become shaly, and a bed of lignite, variable in quality and thickness, is next seen. Near the Woolshed, on the Porter River, the lignite is little more than 12 inches thick, and only the lower half is of good quality. In the Thomas River the bed is thicker, but the quality is not improved. As a fuel this lignite is of no consequence to the district, as there is abundance of timber in the north-western part of the basin, and a seam of brown coal of workable thickness at Craigieburn, ten miles distant.

A very considerable thickness of greenish-grey marly sands succeeds the lignite, followed by grey and yellow sands forming the highest beds of the series.

Except some indistinct fossils found overlying the lignite near the Woolshed, on the Porter River, the upper portion of the Pareora beds have not proved fossiliferous, the underlying part of the series yielding the whole of the collections hitherto made.

FOSSILS OF THE TRELISSIC BASIN, WITH COLLECTION NUMBERS AND STRATIGRAPHICAL POSITION.

Mammalia.—Fragments of cetacean bones (Pareora beds).
Aves.—*Palæeudyptes antarcticus* (Huxley). Reported by Professor Von Haast, but no special horizon given.
Pisces.—Numerous teeth, belonging to several genera.

Name and Collection Number.*	Geological Survey Classification.		
	For. IV.	For. V.	For. VI.
MOLLUSCA.			
CLASS GASTEROPODA—			
Triton spengleri, *Chemn.*, (?), 237, 238	...	*	...
,, minimus, *Hutton*, 237, 238, 241	...	*	*
,, *sp.*, 241	...	...	*
,, *sp.*, 243	...	*	...
Pyrula, *sp.*, 241	...	...	*
Fusus enysi, *MS.*, 231, 235	*	...	...
Buccinum carinatum, *Hutton*, 236, 237, 455	*	*	...
,, *sp.*, 234	*	...	...
,, *sp.*, 241, 243	...	...	*
,, *sp.*, 243	...	...	*
Purpura, *sp.*, 243	...	...	*
Columbella, *sp.*, 243	...	...	*
Ancillaria australis (?), *Quoy*, 236, 241, 243, 455	...	*	*
,, *sp.*, 243, 237	...	*	...
Pleurotoma sulcata, *Hutton*, 236, 255	*	...	...
,, *sp.*, 243	...	...	*
Bela, *sp.*, 241, 243	...	...	*
Voluta elongata, *Hutton*, 243	...	...	*
,, kirki, *Hutton*, 235, 236, 237	*	...	...
,, *sp.*, 243	...	...	*
,, *sp.*, 237, 239, 243	...	*	...
,, *sp.*, 241	...	...	*
Mitra, *sp.*, 239, 241, 243	...	*	*
,, *sp.*, 239, 243	...	*	...
,, *sp.*, 243	...	...	*
,, *sp.*, 451	*	...	...
,, *sp.*, 455	*	...	...
,, *sp.*, 455	*	...	...
Marginella dubia, *Hutton*, 241, 243	...	...	*
,, ventricosa, *Hutton*, 239, 243	...	*	...
,, *sp.*, 241	...	...	*
,, (?), *sp.*, 241, 243	...	...	*
,, *sp.*, 241, 243	...	...	*
Cypræa, *sp.*, 241	...	...	*
,, *sp.*, 241, 449	...	...	*
Natica zealandica (?), *Quoy*, 241, 243, 449	...	...	*
,, solida, *Sowb.*, 236, 441	*	*	* (?)
,, ovata, *Hutton*, 236, 441	*	*	* (?)
,, *sp.*, 239	...	*	...
,, *sp.*, 241, 243	...	...	*
Odostoma, *sp.*, 241	...	...	*
Eulima, *sp.*, 241	...	...	*

* For index to locality numbers on the fossils in the Geological Survey collections, *see* Geological Reports, 1877–78, p. 205.

FOSSILS OF THE TRELISSIC BASIN—*continued.*

Name and Collection Number.	Geological Survey Classification. For. IV.	For. V.	For. VI.
MOLLUSCA—*continued.*			
CLASS GASTEROPODA—*continued.*			
Cerithium nodulosum, *Hutton*, 236, 451, 455, 456	*	...	...
„ *sp.*, 237	...	...	*
Struthiolaria tuberculata, *Hutton*, 236, 451, 455, 456	*	...	...
„ *sp.*, 236	*	...	...
„ *sp.*, 236	*	...	...
Conchothyra parasitica, *McCoy*	...	...	*
Turritella semitrica (?), 241	...	...	*
„ gigantea, *Hutton*, 237, 238	...	*	...
„ tricincta, *Hutton*, 237	...	*	...
„ bicincta, *Hutton*, 241, 243	...	...	*
„ rosea, *Quoy*, 237	...	*	...
„ *sp.*, 241	...	...	*
„ *sp.*, 241	...	...	*
Vermetus, *sp.*, 241	...	...	*
Cladopoda monilifera, *Hutton*, 237, 238	...	*	...
„ *sp.*, 237	...	*	...
Scalaria brownii, *Zittel*, 237, 453	...	*	...
„ *sp.*, 241, 243	...	...	*
Solarium, *sp.*, 239, 246	...	*	...
Turbo superbus, *Zittel*, 236, 451	*	...	...
„ *sp.*, 237	...	*	...
„ *sp.*, 243	...	*	...
„ *sp.*	...	...	*
„ *sp.*, 237, 453	...	*	...
Imperator, *sp.*, 241, 243	...	...	*
„ *sp.*, 237	...	*	...
Trochus, *sp.*	...	...	*
„ *sp.*, 241, 243	...	...	*
„ *sp.*, 243	...	...	*
„ *sp.*, 243	...	...	*
Labio, *sp.*, 243	...	...	*
Gibbula nitida (?), *Adams*, 241, 243	...	...	*
Aderobis, *sp.*, 239	...	*	...
Fissurella, *sp.*, 241	...	...	*
Emarginula striatula, *Quoy*, 241, 243	...	...	*
Calyptræa maculata, *Quoy*, 236, 241	*	*	*
„ *sp.*, 243	...	...	*
Crypta profunda, *Hutton*, 234, 237	...	*	...
„ contorta, *Quoy*, 243	...	...	*
„ costata, *Desh.*, 237, 453	...	*	...
„ incurva, *Zittel*, 236, 451, 456	*	...	...
„ *sp.*, 236, 451	*	...	...
Pileopsis, *sp.*, 239	...	*	...
Hipponyx cornucopia, *Lam.* (?), 241, 243	...	...	*
Dentalium magus, 243	...	...	*
„ solidum, *Hutton*, 237	...	*	...
„ conicum, *Hutton*, 456	*	...	...
Cylichna enysi, *Hutton*, 239, 243	...	*	...
„ *sp.*, 239, 243	...	*	...
Acteonella, *sp.*, 241	...	...	*

FOSSILS OF THE TRELISSIC BASIN—*continued.*

Name and Collection Number.	Geological Survey Classification. For. IV.	For. V.	For. VI.
MOLLUSCA—*continued.*			
CLASS CONCHIFERA—			
Ostrea subdentata, *Hutton*, 243	...	...	*
„ *sp.*, 241	...	...	*
„ *sp.*, 239, 243	...	*	...
„ *sp.*, 239, 243	...	...	*
„ *sp.*, 239	...	*	...
„ *sp.*...	...	...	*
„ *sp.*, 243	...	...	*
„ *sp.*, 243	...	...	*
„ *sp.*, 238	...	*	...
Pecten hochstetteri, *Zittel*, 243	...	...	*
„ hectori, *Hutton*, 239, 241	...	*	*
„ hutchinsoni, *Hutton*, 239, 241	...	*	*
„ polymorphoides, *Zittel*, 239, 243	...	*	...
„ chathamensis, *Hutton*, 239, 241, 243	...	*	*
„ athleta, *Zittel*, 239, 243	...	*	...
„ athleta (?), 239, 243	...	*	...
„ fischeri, *Zittel*, 447	...	*	...
„ *sp.*...	...	...	*
„ *sp.*, 343	...	...	*
Lima bullata (?), *Bron*, 239, 243, 241	...	*	*
„ colorata, *Hutton* (?), 239, 241, 243	...	*	*
„ crassa, *Hutton* (?), 241, 243	...	*	*
„ multiradiata, *Hutton*, 237	...	*	...
„ planicostata, *MS.*, 454	...	*	...
„ *sp.*, 241	...	...	*
„ *sp.*, 241	...	...	*
„ *sp.*, 450	...	*	...
„ *sp.*, 243	...	...	*
Perna, *sp.*, 236	*	...	...
„ *sp.*	...	...	*
Mytilus smaragdinus, *Chemn.*, 236	*	...	...
Modiola albicosta, *Lam.*, 239, 449	...	*	...
„ *sp.*, 239, 243, 449	...	*	...
Crenella elongata, *Hutton*, 243, 241	...	...	*
„ discors, *Lam.*, 239	...	*	...
Arca, *sp.*, 241	...	...	*
Barbatia sinuata, *Lam.*, 239, 243, 449	...	*	...
Cucullæa alta, *Sowb.*, 237, 453	...	*	...
„ ponderosa, *Hutton*, 237, 453...	...	*	...
„ *sp.*, 237	...	*	...
Pectunculus laticostatus, *Quoy*, 236, 237, 453	*	*	...
„ *sp.*, 241, 243	...	*	*
„ *sp.*, 237, 453	...	*	...
„ *sp.*, 451	*	...	...
Limopsis insolata, *Sowb.*, 239, 243	...	*	*
„ *sp.*, 239, 243	...	...	*
„ *sp.*, 451	*	...	...
Cardium spatiosum, *Hutton*, 237, 238	...	*	...
„ *sp.*, 239	...	*	...
„ *sp.*, 243	...	*	...

Fossils of the Trelissic Basin—*continued.*

Name and Collection Number.	Geological Survey Classification.		
	For. IV.	For. V.	For. VI.
MOLLUSCA—*continued.*			
Class Conchifera—*continued.*			
Cardium, *sp.*, 239, 243	...	*	...
„ ***sp.*, 239**	...	*	...
„ ***sp.*, 239**	...	*	...
„ ***sp.*, 239**	...	*	...
Protocardium serum, *Hutton*, 239, 243	...	*	...
Lucina divaricata, *Lam.*, 239, 243	...	*	...
„ ***sp.*, 243**	...	*	...
Kellia, *sp.*, 239	...	*	...
Crassatella ampla, *Zittel*, 236, 451	*	...	...
Cardita, 243	...	...	*
Venericardia intermedia, *Hutton*, 239, 241, 243	...	*	*
„ ***sp.*, 241, 243**	...	...	*
„ ***sp.***	...	...	*
„ ***sp.*, 243**	...	*	...
„ ***sp.*, 447**	...	*	...
Venus zealandica, *Gray*, 237	...	*	* (?)
„ ***sp.*, 238**	...	*	...
„ ***sp.*, 241**	...	...	*
Cytherea enysi, *Hutton*, 236, 451	*	...	...
Dosinia magna, *Hutton*, 237, 238	...	*	...
„ ***sp.*, 241, 243**	...	...	*
„ ***sp.*, 239**	...	*	...
Mysia zealandica, *Gray*, 239, 243	...	*	...
Tapes curta, *Hutton*, 237, 238	...	*	...
„ ***sp.*, 237**	...	*	...
„ ***sp.*, 239, 243**	...	*	...
„ ***sp.*, 239**	...	*	...
Mactra elegans, *Hutton*, 236, 451	*	...	...
„ **attenuata, *Hutton*, 239, 243**	...	*	...
„ ***sp.*, 236**	*	...	...
„ ***sp.*, 458**	...	*	...
„ ***sp.*, 237**	...	*	...
Tellina, *sp.*, 241	...	...	*
„ ***sp.*, 241**	...	...	*
Psammobia zonalis, *Lam.*, 239, 243	...	*	...
„ **lineolata, *Gray*, 239**	...	*	...
Mesodesma, *sp.*, 239	...	*	...
„ ***sp.*, 243**	...	*	...
Corbula, *sp.*, 239, 243	...	*	...
Panopæa plicata, *Hutton*, 239, 241	...	*	*
„ **worthingtoni, *Hutton***	...	* (?)	...
Myacites, *sp.*, 239, 243	...	*	...
Lyonsia vitrea, *Hutton*, 243	...	*	...
Myadora brevis, *Stutch.*, 239	...	*	...
Pholas, *sp.*, 239, 243	...	*	...
„ ***sp.*, 239**	...	*	...
Teredo, *sp.*, 237, 243	...	*	...
Class Brachiopoda—			
Terebratula (?), *sp.*, 243	...	*	...

FOSSILS OF THE TRELISSIC BASIN—*continued.*

Name and Collection Number.	Geological Survey Classification. For. IV.	For. V.	For. VI.
MOLLUSCA—*continued.*			
CLASS BRACHIOPODA—*continued.*			
Waldheimia lenticularis (?), *Desh.*, 239, 241	...	*	*
„ gravida, *Suess.*, 241, 243	...	...	*
„ concentrica, *Hutton*, 241, 239, 250	...	*	*
„ patagonica, *Sowb.*, 450, 239	...	*	...
„ *sp.*, 239	...	*	...
„ *sp.*, 241, 243	...	...	*
„ *sp.*, 241	...	...	*
„ *sp.*, 241	...	...	*
„ *sp.*, 241	...	...	*
„ *sp.*, 239	...	*	...
„ *sp.*, 241, 243	...	...	...
Terebratella suessii, *Hutton*, 241, 243	...	...	*
„ *sp.*, 241, 243	...	...	*
„ *sp.*, 249	...	*	...
Rhynchonella nigricans (?), *Sowb.*, 237, 238	...	*	...
„ squamosa, *Hutton*, 241, 243	...	...	*
„ *sp.*, 241, 243	...	...	*
„ *sp.*, 239, 243	...	*	...
ECHINODERMATA.			
Echinus enysi, *Hutton*, 239, 243	...	*	*
Cidaris (*plates and spines*), 241, 243	...	*	*
Meoma tuberculata, *Hutton*, 239, 243	...	*	...
„ (?), *sp.*, 239, 243	...	*	...
ZOOPHYTA.			
Turbinolia, *sp.*, 243	...	*	...
„ 239	...	*	...
„ 239, 241, 243	...	*	*
„	...	...	*
„ 239, 241	...	*	*
„ 241, 243	...	...	*
Massive coral, 237	...	*	...
Branching corals, 239, 241, 243	...	*	*
„ „ 241, 243	...	...	*
„ „ 241	...	...	*
„ „ 241	...	...	*
„ „ 241	...	...	*
„ „ 239, 243	...	*	...
„ „ 241	...	...	*
„ „ 241	...	...	*
„ „ 241	...	...	*
„ „ 239	...	*	...
„ „ 239	...	*	...
Net or leaf corals, 239, 241, 243	...	*	*
„ „ 239, 243	...	*	...

CURIOSITY SHOP, RAKAIA RIVER, CANTERBURY.

(Notes to accompany a Collection of Fossils from that Locality.)

BY ALEXANDER M'KAY.

On the 24th of September I went to the Malvern Hills, and thence after a day spent in that district I reached the Curiosity Shop, on the Rakaia River. Thither I went for the purpose of collecting fossils, and thus employed I remained at that place till the 5th of February, losing some of the intervening days through unfavourable weather.

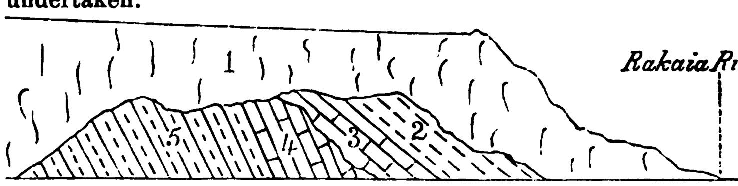
I was specially instructed to undertake this work after I had examined the Trelissic Basin, in order to compare the beds with the sequence which there obtains, so to obtain further information as to the correct classification of our Lower Tertiary and Cretaceo-Tertiary rocks.

During the past few years the calcareous rocks lying at the base of the Tertiary sequence in New Zealand have been largely collected from in a great number of localities; and at the same time another rock, an important member of the Cretaceo-Tertiary system—the Weka Pass calcareous greensands—has received a full share of attention. Nevertheless it has not always been clear, when collecting from one or other of these calcareous rocks, to which division the collections made should be referred, especially if only one of the above calcareous bands be present in the section collected from, or, as often happens, the uppermost calcareous rock has closely approximated in character to the lower one.

There has thus arisen a liability, in classifying collections obtained from many different localities, to mix the types of the two formations, and, with that, a consequent difficulty in determining to which horizon collections from new localities shall be referred. Generally the existence of the two groups of calcareous strata has been recognized, but frequently local developments of one or other group have been referred to the wrong horizon, and in this manner has arisen some confusion as to what really constitute the characteristic fossils of either formation. This being so in the case of the calcareous members of the two groups, if, as has happened through the wrong identification of the overlying limestone, the lower beds of the Cretaceo-Tertiary series chance to be regarded as part of the Lower Tertiary strata, a yet greater degree of confusion is arrived at, the more remarkable of the Cretaceo-Tertiary fossils being thus naturally enough taken as types of Tertiary strata, while at the same time such recent forms as truly belong to Tertiary rocks are taken to show that the wrongly-identified Cretaceo-Tertiary beds are also of Tertiary age. For this reason it is manifestly unsafe to admit into our comparative lists fossils collected from such sections as do not exhibit distinctly the two calcareous members above mentioned; and an equal source of error is sure to arise if, through the absence of the intervening strata, the higher of the two calcareous rocks should chance to rest with apparent conformity upon the lower. In either case a mixture of types is inevitable. That such a danger is by no means an improbable result is but too apparent in comparing such lists of fossils as are given in the various reports dealing with the younger strata of New Zealand. Fully alive to this fact, I have exercised the greatest care in keeping strictly separate the collections of every distinct line of section, and at the same time preserving as separate collections the fossils obtained from every distinguishable horizon. And where a similar lithological character pervades any considerable thickness of strata, the fossils from such are grouped as coming from the upper, the middle, or the lower part, or whatever minor subdivisions it seems possible to make.

The locality known as the Curiosity Shop, on the northern bank of the Rakaia, four or five miles below the gorge of that river, has long been celebrated on account of the great variety and excellent condition of the fossils which occur at that place. The collection which till now has represented this locality in the collections of the Geological Survey having been made several years ago, and prior to the recognition of the distinctness of the two calcareous rocks above mentioned, as separate divisions of different formations, it thus became highly necessary to ascertain if in these the fossils of the two horizons of calcareous rock have not been accidentally mixed. Hence the necessity for making the present collection.

Besides this, the comparison of a collection of Australian Tertiary fossils forwarded to the Colonial Museum by Professor Tait showed that some of the more remarkable fossils of that collection occurred at the Curiosity Shop. So the hope of finding other Australian forms gives further importance to this work being undertaken.



Section at Curiosity Shop, Rakaia Gorge. 1. Gravels of the Canterbury Plains. 2. Pareora beds. 3. Mount Brown or Hutchinson's Quarry beds. 4. Calcareous sandstone. 5. Grey sands.

The accompanying section of the fossiliferous strata exposed at the Curiosity Shop is imperfect, the lowest beds seen belonging to the middle part of the Cretaceo-Tertiary series, while the highest rocks exposed belong to the base of the Pareora formation. Further, the section is very liable to be misinterpreted on account of the absence of the highest division of the Cretaceo-Tertiary rocks (the grey marls), and the apparent absence of rocks belonging to the horizon of the chalk-marls or Amuri limestone.

Further, the beds which yield nearly all the fossils which have been collected from this place being directly overlaid by the dark-greenish sands of the Pareora formation, the lower beds not being separated from these by a marked unconformity, very reasonably leads to the supposition that these latter are much younger than they really are.

The strata here treated of, as far as exposed, are seen only along the lower part of a high terrace forming the northern bank of the river. The lowest beds are loose quartz sands, grey or yellowish-brown in colour, these forming about one-half the entire thickness of the beds seen. On these rests a thick bed of calcareous sandstone, sufficiently hard in places to form a building-stone of fair quality. This rock resembles the Mount Somers and Oamaru stone, not containing the glauconite grains of the Weka Pass calcareous greensands. The upper surface of this harder calcareous rock has, between it and the next overlying, irregular beds and pockets of tufaceous clays, sometimes extending a considerable distance as though marking a distinct horizon, but as often occurring at various horizons in the next beds, overlying the more compact calcareous sandstones. Ten or twelve feet of calcareous sands overlie the principal clay-band, dividing these from the lower and more compact rock. Near its upper surface this higher calcareous bed becomes highly charged with what appear to be grains of glauconite, and eventually passes into a bed of greensand. This is the principal horizon for the collection of fossils.

The upper calcareous beds passing into greensands are overlaid by loose grey quartz sands, in which a bed of badly-preserved shells occurs. These sands, having a thickness of about 15 feet, are overlaid by dark-grey or greenish sands, the highest stratified rock in the section.

Except the calcareous rocks, which form a low bluff, projecting so as to form an angle in the direction of the terrace, all the other rocks are much obscured by the shingles of the higher part of the terrace sliding over and covering them up.

The lower sands, up to the under-surface of the calcareous rocks, are, I have little doubt, the same as those seen along the northern slope of the Harper Hills, between the Selwyn and Hororata Rivers, in the Malvern District. In the Malvern Hills these sands close the sequence of stratified sediments which intervene between the coal-beds and the outer fringe of volcanic rocks bordering the Canterbury Plains. In the Malvern Hills the conformity of these sands with the underlying coal-bearing strata has not yet been called in question, Professor Von Haast considering "that, instead of the calcareous sandstone (Weka Pass stone), the series is capped by the anamesitic or dolerite rocks" of the Harper Hills, and in the same paragraph pointing out that in the neighbourhood of Timaru, where the Weka Pass limestone also occurs, it is "subdivided by several *coulées* of the anamesites identical with that of the Malvern Hills." As the strike of these sands in the Harper Hills is such as to carry them close past the Curiosity Shop, I cannot see that we can avoid concluding that the lower sands exposed in the latter place are in position and age the same. Further, as we have the testimony of Professor Von Haast showing that the anamesitic rocks which overlie these sands in the Malvern Hills are actually interstratified with the calcareous rocks closing this series in the neighbourhood of Timaru, the anamesites in the Malvern Hills are therefore the equivalents of this calcareous rock, and part of the underlying sands must represent the Amuri limestone as the next rock underlying.

With this, the unavoidable conclusion, as far as the sandy beds are concerned, I cannot but agree, and am therefore bound to consider the lower sands at the Curiosity Shop as belonging to some part of the Cretaceo-Tertiary series; but, there being manifestly an unconformity between these beds and those which close the section at the Curiosity Shop, the location of this becomes a matter of the highest import. (Geological Reports, 1871, p. 25.)

Volcanic outbursts have taken place in New Zealand at several different epochs since the advent of Cretaceous time; igneous rocks, as contemporaneous floes of molten matter, being frequently detected between the coal-bearing strata and the higher calcareous members of the Cretaceo-Tertiary series, as seen in a great number of sections in both Islands, and great accumulations of tufaceous matter have in some localities taken the place of the boulder-sands and concretionary greensands.

A second display of volcanic energy took place after the close of the Cretaceo-Tertiary period, during Eocene times, which latter outburst was evidently preceded by an upheaval and consequent denudation of the Cretaceo-Tertiary rocks. So that, while the volcanic rocks of this period are always followed by strata belonging to the Upper Eocene period, these themselves rest on many different members of the Cretaceo-Tertiary series, as well as on yet older rocks.

A yet later outburst took place subsequent to the deposition of the rocks belonging to the Pareora formation, to which belong the volcanic rocks of Mount Horrible and the neighbourhood of Timaru.

The second of these displays, marking the close of the Cretaceo-Tertiary period, is that only which concerns us in considering the relations of the different members of the Curiosity Shop section.

It is true that in the Curiosity Shop section there are no solid floes of volcanic rock, and the tufas also are scarcely represented. Yet, when we consider that in other localities not very remote such form distinct and well-marked horizons, always underlying the lowest beds of the Pareora formation, it is evident that traces, however slight, of their presence in this section must have a meaning commensurate with their importance in other localities.

Within the town of Oamaru, and in the northern part of the hills between there and Cape Wanbrow, solid floes of volcanic rock rest on beds which are in the same district seen to underlie the Ototara limestone. These volcanic rocks are however unconformably younger than the beds upon which they rest in the Cape Hills, and betray evidence of their exact age where they are interbedded with thin beds of altered limestone belonging to the Hutchinson's Quarry beds.*

I have already quoted Professor Von Haast with reference to the interstratification of volcanic rock between limestones of Lower Tertiary age near and to the north of Timaru; but, as bearing more directly upon the point which I wish to settle, because occurring in a locality not so distant from the Curiosity Shop, I will again venture to quote him in giving the sequence of rocks seen at Fossick Point, on the right bank of the Ashburton River, where the following succession of beds was observed :—

"No. 1. Limestone in flaggy layers, consisting principally of pieces of shells and corals."

"No. 3. Dark-brown volcanic tufas, with numerous lapilli of basaltic lava enclosed."†

"No. 6. Calcareous greensands, becoming towards the centre almost black from grains of glauconite."

Bed No. 1 is 15 feet, and Bed No. 6 is 30 feet thick.

North of the Ashley River, in the Glentui Creek, the volcanic rocks as solid lava streams are seen within a short distance resting first on the bed of the creek upon the Teredo greensands, and a little to the north on calcareous sands representing the Weka Pass calcareous greensands. At Oxford they are seen resting on Old Secondary or Palæozoic rocks; and further to the west, on the banks of the Eyre River, eight miles from Oxford, they are seen as solid streams of considerable thickness resting upon chalk representing the Amuri limestone.

In the Trelissic Basin the two principal limestone members of almost every section which can be there examined are separated by a thick bed of tufaceous volcanic matter, in which pieces of solid, denser rock are not infrequent.

Having, I think, made it clear that these volcanic products of the second period of eruption here referred to mark an unconformity between the stratified sediments which they separate, I will now, returning to the Curiosity Shop section, continue the description of the beds yet remaining to be treated of.

The quartzose sands forming the base of the section, it can scarcely be doubted, belong to the Cretaceo-Tertiary series. The

* *See* Report on the Oamaru and Waitaki Districts, Geological Reports, 1876–77.

† Nos. 2, 4, and 5 are left out as unimportant, for which *see* Geological Reports, 1873–74, p. 16.

overlying limestones, separated by the irregular beds and pockets of tufaceous clay, are, I conclude, of different ages. The lower part I refer to the Ototara group of the Cretaceo-Tertiary series; while the higher part I consider to belong to the Hutchinson's Quarry beds or the Mount Brown limestone, the higher beds of the section being referred to the Pareora formation, which everywhere succeeds with apparent conformity.

There is a necessity for having an unconformity somewhere in this section, since it cannot be supposed, with the evidence to the contrary which has already been adduced, that the Pareora beds are conformable to the lower beds of the Cretaceo-Tertiary series.

The upper surface of the calcareous part of the section yields ample evidence that it belongs to the same period that the Hutchinson's Quarry beds belong to, the numerous species of fossils collected proving this beyond doubt.

It remains therefore that the unconformity must be placed either below the limestones and calcareous greensands altogether, or—where I incline to put it—between the upper and lower parts of this division.

This arrangement would be perfectly in harmony with what has been observed elsewhere of these beds, and would explain the occurrence of *Lima lævigata,* which is seen as fine large specimens in the lower part of the calcareous beds, where it is associated with *Pecten hutchinsoni* and numerous Brachiopoda.

All the shells and other fossils collected come from the highest of the upper calcareous rocks. The overlying loose sands have been removed from an area some 30 feet in length by 10 feet broad, and on this surface a great number of the smaller shells, &c., were picked up. Collecting these, I next turned over a considerable amount of the soft underlying rock, and in this I obtained many species which, in weathering out, suffered so much damage that, as weathered specimens, they were not worth preserving. With the exception of *Lima lævigata* the lower fossiliferous beds appeared to differ mainly in the absence from them of many of the forms found in the higher beds, and, the fossils in this lower part of the calcareous rocks being difficult of extraction, I contented myself with those more easily obtained from the higher beds.

The entire collection comprises 2,700 specimens. Fully one-half of these are Brachiopoda, various forms of *Waldheimia* absorbing nine-tenths of these. *Terebratella suessii* is represented by about one hundred specimens. *Rhynchonella* is rare, and there are in the collection only two specimens of *Terebratella cruenta*. *Pecten hochstetteri,* making the greatest show in the collection, is very numerous, though perhaps not more abundant in the beds than the cup-shaped Bryozoa of Mount Brown. Echinodermata, of which by far the most numerous form is *Hemiaster* *posita*, is represented by fully one hundred individuals, excluding numerous spines, of which a considerable collection was made. Amongst these latter are many examples of a large smooth spine having a fibrous radiate structure, similar to that seen in the guard of a belemnite. Of this particular fossil one perfect example was found, all the others being broken in length ranging from one to three inches. The genus *Lima* is well represented, and, next to *Pecten hochstetteri*, is the most abundant form of Conchifera.

Of the twenty species of Gasteropoda which the collection contains, each species is, except in a few cases, represented by a small number of individuals, and, except the genera *Scalaria* and *Patella*, all are in the condition of casts.

Most of the bivalve mollusca are also represented by casts only. The exceptions include the genera *Ostrea, Pecten, Lima*, and *Pinna*.

Amongst the Brachiopoda there is scarce a single example of a cast, they being, in this respect, remarkably different from the higher forms.

After working this collection out and preparing part of it for exhibition in the Museum, the following list has been compiled, and is here given as affording a general view of the character of the collection :—

Fusus, *sp*.
Fusus, *sp*.
Fusus, *sp*.
Fusus, *sp*.
Fusus dilatatus.
Struthiolaria senex.
Turritella gigantea.
Phorus, *sp*.
Calyptræa maculata.
Turbo, *sp*.
Imperator.
Ancillaria australis.
Voluta pacifica.
Marginella dubia (?).
Cassis, *sp*.
Natica solida.
Scalaria browni.
,, lyrata.
Patella, *sp*.
Dentalium solidum.
Panopæa plicata.
Zenatia, *sp*.
Mactra (?), *sp*.
Tellina.
Tellina, *sp*.
Venus, *sp*.
Cardita, *sp*.
Cardita, *sp*.
Cyprina, *sp*.
Cyprina, *sp*.
Cardium (?), *sp*.
Lucina divaricata.
,, intermedia.
Mysia globularis.
Mysia, *sp*.
Crassatella trailli.
Pinna, *sp*.
Cucullæa alta.
Pectunculus, *sp*.
Anatina tasmanica (?).
Ostrea, *sp*.
Ostrea, *sp*.
Pecten gemmulatus.
,, chathamensis.
,, hutchinsoni.
,, hochstetteri.
Lima multiradiata.
,, paleata.
,, paucisulcata.
,, crassa (?).
,, lævigata.
Teredo, *sp*.

Waldheimia lenticularis.
,, triangularis.
,, triangularis, *var.* a.
,, triangularis, *var.* b.
,, triangularis, *var.* c.
,, patagonica (?).
,, patagonica, *var.* a.
,, *n. sp.*, No. 1,
,, *n. sp.*, No. 1, *var.* a.
,, *n. sp.*, No. 1, *var.* b.
,, *n. sp.*, No. 2.
,, *n. sp.*, No. 3.
,, *n. sp.*, No. 4.
Terebratella dorsata (?).
Terebratella gaulteri.
,, suessii.
Rhynchonella nigricans.
,, squamosa.
Pentacrinus stellatus.
,, stellatus (?).
Pentacrinus.
Echinus, *sp.*
Cidaris, *sp.*
Hemipatungus formosus.
Hemiaster posita.
Meoma crawfordi.
,, tuberculata.
,, tuberculata, *n. sp.*
Spines of Echinodermata with radiate fibrous structure.
,, ,, smooth.
,, ,, fluted.
,, ,, tuberculated.
,, ,, thorny.
,, ,, branching.
,, ,, expanding to cup at top.
Turbinolia.
Coral, branching, smooth dense structure, cells minute.
,, ,, cylindrical cells minute and wide apart.
,, ,, flat, cells numerous and in lines.
,, net, perforations large, cells minue.
,, net, perforations small, cells minute.
,, tubular, not perforated, cells large with smaller cells between.
Bryozoa, cup-shaped.
,, in irregular masses.
,, adhering to and covering shells, &c.
Balanus, *sp.*
,, plates of.
,, ,,
,, ,, (?)
Serpula, free-tubular, curved, tapering irregularly.
,, adhering to shells and other objects.
,, spirally coiled.
Shark teeth.
Crustacean fragment.
Bones of *Palæeudyptes antarcticus.*

ON THE OLDER SEDIMENTARY ROCKS OF ASHLEY AND AMURI COUNTIES.

BY ALEXANDER M'KAY.

INTRODUCTION.

THE work, the main results of which are embodied in this report, was undertaken in conformity with a schedule of instructions by the Director of the Geological Survey. The examinations bearing upon the present subject were effected during three different journeys in distinct localities. In each district a common object was kept constantly in view — viz., the determination of the age, and relative position to the other rocks of the same district, of that group of strata hitherto known as the "Mount Torlesse annelid beds." Therefore, although the different localities where evidence bearing upon this subject was obtained are as far apart as is the Wairau Gorge from the Malvern Hills, the rocks present in each can be conveniently treated of in one report.

NARRATIVE.

According to my instructions I began the first part of this work on the 16th of October last by an examination of the lower part of the Ashley Gorge. My intention was to have followed the bed of the river from the lower to the upper end of the gorge, but its swollen state prevented my doing so, as it requires to be crossed and recrossed continually in passing through the gorge. But, apart from this consideration, the extremely tortuous course which the river follows, and the highly contorted, broken, and faulted condition of the rocks exposed in its banks, renders this natural section too perplexing in its details to be comprehensible without accurate survey.

I therefore kept to the north-east, and from Glentui Creek followed a mountain track crossing the Mount Thomas Range to the Wharfdale Station, in Lee's Valley, Upper Ashley River.

On reaching Okuku River I remained for some days examining the ranges to the westward, towards the sources of the Ashley River, and ascended Block Hill, one of the highest peaks in this vicinity; but, as most of the higher part of this mountain was then deeply covered with snow, less valuable results were obtained than might have been the case had it been later in the season.

On October 21st I went to the Upper Okuku Valley, where I was engaged till the 25th collecting from and examining an important series of rocks developed in that neighbourhood. On the 27th and 28th of October I examined the Okuku and Mount Karetu Ranges; and on the 28th from White Rock Station I went to Rangiora, and thence by rail to Oxford. At Oxford I was employed as described in another report* till the 2nd of November, from which place I returned to Wellington on the 4th of November.

With the same object in view which led to the work already done in the Upper Ashley District, I again left Wellington on the 10th of November. Going by steamer to Nelson, I made a short stay at Wakefield, making a further examination of the Maitai limestone, five miles to the south-east, near Sellon's station.

On the 13th of November I went by the Upper Motueka and Top House to the Wairau Valley. Hence I followed up the Wairau Gorge to the Rainbow Junction and Tarndale. Following the Alma River to its junction with the Acheron, and the latter to the junction of that with the Clarence, I thence followed the latter river up to the foot of Jollie's Pass, crossing which I reached the Hanmer Plains, and by the Leslie Pass again entered the Canterbury District on the 26th of November. Some days were then employed in examining the railway cuttings along the Weka Pass section, which was in course of construction; and on the 5th of December I reached the Malvern Hills, and crossed Porter's Pass to Castle Hill. From this point the country was examined in various directions, and along the West Coast Road as far as the Bealey crossing of the Waimakariri River, particular attention being given to the Tertiary and Cretaceous beds of the Trelissic Basin, until my return to Wellington on the 23rd of December.

DESCRIPTION OF THE DISTRICT.

Without expanding it to an extent incompatible with the whole, no justice can be done to this part of the report. It is sufficient for the present purpose to state that the country is excessively mountainous, and crossed from west to east by a number of large rivers taking their rise in the main chain dividing the east and west slopes of the Island; and that these rivers in some part of their course, either on the seaboard or inland, cross plains of considerable extent.

GENERAL GEOLOGICAL STRUCTURE.

Palæozoic rocks mainly belonging to the Carboniferous period, but including in the north-west corner of the district rocks of Devonian age, form a great synclinal depression, the edges of which appear along the north-western and south-eastern borders of the district. Contorted and much disturbed as these rocks are, and frequently, as they do, showing an uncertain dip, they yet in the main strike parallel to the main axis of the island. And although their area of exposure is considerably less than that of the younger rocks, structurally they are of greater importance. Within the two sides of this general synclinal arrangement, but nearer the western than its eastern side, an anticline of the same

* *See* Report on the Discovery of Chalk near Oxford, p. 49.

rocks divides it into two. The central anticline can be traced south beyond the limits of the district under report, but as yet has not been shown to exist north of the Hurunui River. These rocks, in the absence of older, may be looked upon as forming the framework of the country east of the main chain.

Within the syncline—or rather the two synclines if speaking of the south-west part of the district—appears a great thickness of younger rocks ranging in age from Permian to Oolitic times. These younger beds form a great part of the mountains within the Canterbury District, and strike north-east in the Nelson part of the district as a broad belt, not terminated at the north-eastern boundary.

Instead of striking as well-defined anticlinal ridges and corresponding depressions in the direction of their greatest length of exposure, these younger rocks make within the greater syncline transverse superficial anticlines and depressions, and yet, near the edges of the great syncline, strike parallel thereto. As a consequence the lines of outcrop vary very much in the direction which they take, and the general structure appears to be as described by Professor Hutton in his report "On the North-east District of the South Island,"* in which, speaking of the rocks forming the Kaikoura formation of that report, he says, "The formation, which must be of great thickness, does not appear to me to be thrown into parallel folds, but into huge domes and cup-shaped depressions." This opinion, which was grounded upon observations made principally amongst the Spencer Mountains, has been borne out as far as the district to the south-west was examined on the present occasion.

The disturbances which have given rise to this peculiar disposition of the younger beds are best explained by supposing that these were originally, prior to the formation of the great syncline, thrown into a number of anticlines and corresponding depressions striking across this area in a north-west and south-east direction, which, as the great syncline with its central lesser anticline developed itself, were acted upon transversely so as to produce the effects which we see.

Table of Formations present in the District referred to in this Report.

	Formation.	Age.
VIII.	Putataka formation	Oolite.
IX.	Bastion series	Lias.
X.	Otapiri series	Upper Trias.
	Wairoa series	Middle Trias.
XII.	Annelid beds	Lower Carboniferous.
	Maitai slates	Lower Carboniferous.
	Te Anau series	Upper Devonian.

* Geological Reports, 1873-74, p. 32.

Neither the Cretaceo-Tertiary nor the Tertiary rocks have been included in the above table, as these will be dealt with separately.

TE ANAU SERIES.

The Te Anau series is not largely developed, it being confined to the Wairau Valley, in the north-west corner of the district. Its rocks and their arrangement have been described in last year's report "On the District between the Wairau and Motueka Valleys."* They were not on this occasion examined with any care, and their exact limits have not been defined. But in the ranges east and west of the Wairau Valley they may be considered present from the mouth of the Branch River to a point ten miles above Top House, or to within eight miles of the junction of the Rainbow River with the main stream.

These beds form an anticlinal ridge, now greatly destroyed through the erosion of the Wairau Valley below the Branch River, being wholly removed in the lower grounds, where an underlying metamorphic series is exposed.

MAITAI SERIES.

Including—a. *Maitai limestone.*
b. *Maitai slates and sandstones.*
c. *The annelid beds.*

a. *The Maitai Limestone.*—This division of the series was not examined, nor is it known to occur within the limits of the district described. It was, however, examined near Wakefield, in the Waimea District, in the hope that fossils might be found which would throw light on the main subject of this report. *Spirifera glaber* and a *Fenestella* were the only fossils added to those already known from this limestone, while the associated sandstone and slate rocks have not as yet proved fossiliferous. Therefore the hope that the beds *c*, characterized by their peculiar fossil, might be found in this district has not been realized.

b. *Maitai Slates and Sandstones.*—These, as the higher rocks seen in the typical section along the Maitai River, have been identified elsewhere, mainly on account of the similar lithological characters of the rocks reckoned their equivalents. The auriferous rocks of Reefton, which are supposed to belong to this division of the Maitai series, have in them none of the red slates which distinguish the typical section. They, however, display well the pale-green silky slates which form part of the lower beds of this division at Dyer's, on the Maitai River, and, being underlaid by fossiliferous Devonian rocks, are reasonably referred to this part of the Maitai series.

The rocks in the vicinity of Ross, twenty miles south of Hokitika, are likewise, on account of a mineral resemblance, referred

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* Geological Reports, 1878–79, p. 108.

to this division, neither of these developments resembling the Permian or Old Secondary rocks in other parts of the South Island.

East of the main range the red and green slates of the Maitai section have as yet only been found in a belt of country stretching from the Upper Rangitata Valley north-east through the higher part of Mount Potts, in the direction of the upper part of the Rakaia Valley. Here the identification of the beds rests upon the inferior position which they occupy to proved beds of Permian age, and the identity of their mineral character with the rocks of the Maitai section.

The same rocks have during the present trip been found in a spur of the Black Range, which, stretching to the northwards, separates the Cass River from the upper part of the Waimakariri River, where the different texture of the rocks in this bold and rugged spur range at once distinguishes them from the rocks of the adjoining ranges to the eastward. The extent of these rocks in this locality is unknown, but they appear continuous for some distance both to the north and south.

The green slates with sandstones and beds of slate-breccia are seen *in situ* in the road-cuttings and spurs of this range on the south side of the Waimakariri, between the junction of the Cass River and the Bealey crossing of the Waimakariri.

Red slate is abundant in the Cass River bed, but this may prove to be derived from a younger formation in which red slates are also found.

The Maitai slates strike north and south, and dip at high angles to the east. Against them, coming from the eastward, younger strata abut at right angles. To the west there appears to be a fault, as rocks appear in this direction which, on being followed westward, are seen with other rocks to lie upon these green Maitai slates. For which reason a line of fault must be placed here, or, if the westward rocks in the vicinity of the green slates are proved to underlie in mapping the country, the line of fault must be placed yet farther to the west, somewhere in the vicinity of Arthur's Pass. The difficulty may be overcome in another way; for by supposing that the green slates form an anticline between the mouth of the Cass and Smith's Camp on the Bealey River, with a syncline yet further to the west, the appearance of the Maitai slates in the Taipo Range would be in perfect harmony with such an arrangement.

The latter supposition involves the necessity of regarding the beds immediately west of the green Maitai slates, on the Cass River, as yet lower rocks of the same series. Thus placed they would become the equivalents of the dark slates and sandstones which overlie the Maitai limestone in the Dun Mountain section, and at the lower end of the Limestone Gorge on the Upper Maitai. Admitting the possibility that this is the true arrangement of the strata, the beds in question have to be described under the present heading as belonging to Division *b* of the Maitai series, and not, as originally intended, under Division *c*.

As yet our information is perhaps not sufficient to enable us to refer rocks occurring in distant localities to the lesser divisions of the typical section of the Maitai rocks, and it will in the meantime serve all practical purposes that the strata be referred to the Maitai formation as a whole. This course however was scarcely available in dealing with the beds treated of in the present report, as the next subdivision, *c*, has frequently been referred to formations which avowedly were not intended to include the rocks of the Maitai section; and on this account Division *c* has either to be treated of as a separate formation or under the classification here adopted.

The rocks between the Cass and the Bealey which have given rise to this digression consist of grits and sandstones, with sandy shales and slates of finer grain. With these beds are nests or lenticular patches of dark-grey compact limestone. In the sandy shales, which are of a dark colour, coarse impressions of plant-remains are abundant. These occur in the sandstones as well. The limestone looks a most unfavourable rock for the occurrence in it of fossil shells: yet from a block of this a single specimen was obtained. The fossil is imperfect, but can with some degree of confidence be referred to as the same as the Dun Mountain *Inoceramus*, from the lower Maitai rocks. It is sufficiently preserved to show the fibrous structure of the shell.

The rocks of this division of the Maitai series are not again seen east of the main chain of mountains, but appear to have a considerable development in the Taipo Ranges, on the south side of the valley of the Teremakau River.

With Mr. Cox, Assistant Geologist, I examined these rocks during the early part of 1876, and from his report on this part of the Westland District take the following remarks: "At a short distance on each side of the point of junction between them [the Maitai slates] and the metamorphic rocks the strike of the two differs by about 30 degrees, that of the Maitai slates being north 40 degrees east, and dip south-east at an angle of 70 degrees: the strike of the mica-schists being north 10 degrees east, and dip south-south-east at an angle of 75 degrees. The Maitai slates thus overlie the metamorphic rocks unconformably. They strongly resemble the auriferous slates in their lower beds, and the Maitai sandstone is, in all its characters, identical with that of the auriferous series."* How far to the south-west are these rocks developed along the western slopes of the main chain has not been ascertained, nor have the same rocks been traced north-east beyond the Teremakau Valley. They probably occur on the

* Geological Reports, 1874–76, p. 77.

western slopes of the main divide continuously, till in the St. Arnaud Range they identify themselves with the southern extension from Nelson of the Maitai slates in this direction.

Rocks similar in character to the Maitai slates were detected in the larger creeks coming from the St. Arnaud Range, in the Upper Wairau Valley. But these mainly lie in the higher and western part of the range, and *in situ* did not come under observation. Where last seen in this part of the district they are near Top House, arranged as a syncline which to all appearance is inverted, dipping to the south-east; but farther to the south-west, near the sources of the Rainbow, the eastern side of this must, on the disappearance of the Te Anau series, form an anticline which, on the eastern side, dips so as to underlie the younger rocks developed near the sources of the Wairau River.

Regarding the Maitai limestone as immaterial in the discussion, it is only in connection with the Te Anau series that the relations of the Maitai slates and sandstones can form a subject of debate. Elsewhere marked unconformity separates these beds from the rocks of whatever series they may chance to rest upon.

I have already, in last year's report on the district between the Wairau and Motueka Valleys, discussed this subject, and shall be called upon to do so a second time in connection with the work of the present season carried on in the Hollyford Valley, so that it is quite unnecessary to take the matter up in the present case.

c. *Annelid Beds.*—Before giving a description of the beds themselves, or stating such facts as have been added to those already recorded respecting these beds, some general remarks appear to be necessary in order that a somewhat difficult subject may be so treated of as to be clearly understood.

First of all, with respect to the nomenclature of the beds, it is here that our difficulties begin, as hitherto they have been spoken of as "the Mount Torlesse Annelid Beds." Professor Von Haast, in his late work "On the Geology of Canterbury and Westland," includes this division of the Maitai series as part of the Mount Torlesse formation of that work. But unfortunately not merely the Carboniferous annelid beds are so included, but with them rocks of very different ages, ranging from Permian to Oolitic times; while the typical rocks of that formation occurring as diabases, cherts, &c., in Mount Torlesse itself have no connection with the annelid beds, which latter are nowhere recorded to occur actually in the rocks of Mount Torlesse. It is certain, at least, that in the available records of the Canterbury Provincial and the New Zealand Geological Surveys no direct mention is made of the occurrence in Mount Torlesse of the fossil distinguishing these beds.

The presumed absence of the fossil, with the lack of any statement to the contrary, and the presence of rocks other than those yielding it as prominent strata in the Mount Torlesse Range, together with the fact that these, as diabases, cherts, &c. (now known to be of Triassic age), are cited as typical rocks of the Mount Torlesse formation above mentioned, which is said to be of Carboniferous age, and yet in all its rocks is not of that age, renders manifest the impossibility of correlating the classification of Professor Von Haast's late work with that here adopted.

The placing of these annelid beds in their correct position is unquestionably the most difficult problem that has yet to be dealt with in perfecting the classification of the older sedimentary rocks of New Zealand. This in some measure arises from the facts already stated, but is also due to the circumstance that, with the exception of the one fossil from which the beds take their name, no others have been found. The difficulty is further increased by a lithological resemblance of the strata to many of the younger rocks found in the same district, so that, when the age of such similar rocks cannot be decided, the presence of the annelid is necessary to prove the distinction.

So much therefore depends upon the presence, absence, or correct identification of the annelid, which importance it must retain until other and more determinate forms are discovered, that it becomes necessary to say a few words descriptive of the fossil itself, and to catalogue the localities in which it is found.

Of this fossil there appears to be more than one variety, but, being confined to the same strata, the occurrence of either form is matter of indifference with relation to the purpose which they serve —viz., the identification of the strata (often widely separated) in which they are found.

Of the two varieties, that which has the widest distribution is most abundant and best preserved in strata exposed near the lower end of the Ashley Gorge, forty miles north of Christchurch. As there found this organism is a tapering tubular calcareous body, varying from one to three inches in length, the greater diameter of the larger specimens being not more than a quarter of an inch. In most cases when they occur between the bedding planes of the rock they are found flattened by the pressure of the overlying stratum, but when found vertical or highly inclined to the bedding planes they preserve their cylindrical form. In their fossil condition the walls of the tube are sufficiently thick to have resisted any ordinary amount of pressure exercised by the overlying beds, and therefore it may be doubted if they have always been calcareous as they now are. As it is possible that the name given to this fossil may have led to a misconception of its real nature, and if, as I suppose, it was fixed to a particular spot and incapable of locomotion, it will be obvious that the annelid trails and markings found in many of our sedimentary rocks cannot be referred to this fossil as having produced them.

Annelid trails were noticed in Dr. Von Haast's reports as early as 1862, and are common in the collection from Maitai slates of Nelson, and from the Permian rocks of Otago, Westland, and

Southland, and in various parts of the mountains of Canterbury.* These, though necessarily very distinct from the Ashley Gorge fossil, have not always been understood to be so.

The fossil as here described occurs in immense numbers at the Ashley Gorge; yet there is in the rocks of that place a noticeable absence of any markings that might be taken for annelid trails. The inference to be drawn from this fact is that, whatever may be shown to be the true character of the fossils there, they were during life fixed to one place and incapable of producing such trails.

It has already been hinted that in particular beds they occur not scattered indiscriminately between the bedding planes of the rock, but in a vertical position. At one particular point, where a rib of rock crosses the bed of the river, immense numbers of them are seen so placed, and it cannot be doubted that this is their natural position.

No specimens hitherto obtained from the east coast of the South Island, or from the neighbourhood of Wellington, in the North Island, have other than a straight tubular form. But while this most common type is abundant on the west coast of the South Island, there are others so bent that the two ends of the fossil almost meet in a circle.

Professor Von Haast has at various times collected or observed these fossils on the Mount Cook Range, on Mount Forbes, near the source of the Rangitata, and on Mount Observation, in the north-east part of the Mackenzie country; also near the sources of the Rakaia River, and at many places in the Malvern Hills, at the lower gorge of the Waimakariri, at the Ashley Gorge, and in the gorge of the Glentui Creek; also on the East Coast, near the mouth of the Hurunui River. It thus appears that although this fossil has been collected from no less than nineteen or twenty different localities it is nowhere spoken of as actually having been collected from Mount Torlesse, except being incidentally mentioned on one occasion as being the "annelid of Mount Torlesse."†

In speaking of the fossil, the beds in which it is found have necessarily been alluded to as occurring in a great number of places. To many of these localities, and such of them as are beyond the boundaries of the present district, it will be needless to refer again.

The annelid beds have not been traced in the eastern front

* The first specimen placed in the Geological Survey Museum at Wellington was collected by Dr. Hector in 1868, with the note that "in the Kowhai Valley the Mount Torlesse beds are overlaid on the east by blue massive slates, fine-grained breccias, and coarse sandstones, much indurated and broken. The latter beds at the accommodation-house at the east base of Porter's Pass contain fossil ferns, and a little further down the valley the slates of a dark colour contain the so-called Tentaculites."

† Dr. Haast: Geological Survey Reports, 1871-72, p. 85.

ranges south of the Rakaia Valley. At Redcliffe, where the fossil occurs, the beds strike north-east, having generally a north-west dip. Obscured for a time, being covered by the alluvium of the Rakaia Valley, they again appear in the ranges to the west of the Malvern Hills, reaching as far north as Porter's Pass, on the West Coast Road, where, as highly contorted rocks seen near the summit of the Pass, they appear to make junction with a younger formation.

The western spurs of the Mount Torlesse Range are composed of rocks that in character closely resemble the annelid beds; yet, although a vast amount of shingle and other *débris* as large blocks brought down from the slopes of the range were examined with all care, no trace of fossils could be discovered. On the south-eastern side of the range, in the upper course of the Kowhai River, the greater part of the rocks belong to another and younger formation.

The high ranges to the west of the Trelissic Basin may in part be formed of annelid beds, but it is certain that the only rocks identified in that direction belong to younger strata.

The numerous examples of the fossil annelid found in the bed of the Selwyn River, where it has its course through the central part of the Malvern Hills, does not prove the existence of the rocks yielding it east of the Four Points Range and Frank's Knob, the fossils being apparently brought down from the ranges further to the north-west, but proves that the beds are developed to some extent in this direction, whence they strike north-east, and may form part of Russell's Hill Range, terminating for the time near the Kowhai Corner. To this part of the district but little time was devoted, as, had a careful examination of it been entered upon, time, more than lay at my disposal, would have been required to settle the numerous points which have already been raised and were likely to arise with regard to the sequence of the older rocks present. I therefore determined to seek a fresh field in which the relations of these same strata might be exemplified in a clearer manner, less capable of double interpretation.

In that part of the Canterbury Plains which intervenes between the northern part of the Malvern Hills and Oxford Bush the shingle formation hides the annelid beds, with a single exception, now to be mentioned.

At Gorge Hill, where the bridge over the Waimakariri forms the communication between the Malvern and Oxford Districts, annelid beds are seen forming the abutments of the bridge. In these the fossil is found, though not plentifully.

Another isolated outcrop appears at View Hill, overlaid by volcanic rocks. Near this latter locality the annelid beds next appear in the banks of the Eyre River, where the western branch first touches upon the Oxford Bush. The beds are not well exposed at this place or at View Hill, and are not fossiliferous, so that their identity in these places may be disputed.

Farther to the north-east, between the last-mentioned place and the town of Oxford, indentations of the adjoining plain encroach upon or wholly cover the annelid beds, its gravels in places sweeping over the annelid beds and touching upon the next formation to the north-west. Before reaching the town of Oxford the annelid beds have acquired a width of exposure varying from a mile to a mile and a half, and immediately north of the town yield their characteristic fossil.

From Oxford north-east to the Ashley Gorge these beds are continuous, forming the south-eastern or front ridge of hills which form part of the block of mountains in that direction; thence they are continued north-east as a distinct range to the gorge of the Glentui Creek, separated by a depression to the north-west from the westerly extension of the Mount Thomas Range.

Beyond the Glentui Creek, *i.e.*, to the north-east of it, these beds have not been traced for any distance, and it is probable that they shortly disappear in this direction, heavy terraces of coarse angular material resembling glacier *débris* reaching close up to the foot of the range in the higher grounds bounding the Garry stream, while the surface material brought from the immediate vicinity indicates the presence of the diabases of the Malvern Hills.

Further than the fact that the fossils distinguishing them are noted by Professor Von Haast as being found near the mouth of the Hurunui River, the annelid beds are not again seen or known to occur on the East Coast south of the Hurunui Plain, secondary rocks forming the ranges bounding the western side of the Hurunui Plain, from the mouth of the Mandanus to the gorge of the Waiau-ua, beyond which the Leslie Peaks and the southern slopes of the range separating the Hanmer River from the Clarence Valley are composed also of younger rocks.

On following the inland track to Nelson across Jollie's Pass, no annelid beds can be detected till the top of the Pass leading from the north-east corner of the Hanmer Plains into the Clarence Valley is reached. These, where first met on the top of the saddle, are highly contorted dark-coloured slates, closely resembling the annelid beds, and are wedged in between Triassic beds to the north and west, and yet younger beds to the south. It may be that closer examination will show that these contorted strata belong to one or other of the younger formations present, and that the annelid beds do not make their appearance for some distance farther down the Clarence River.

The rocks of which the Leslie Peaks are built up, and which also form the southern slopes of the range dividing the Hanmer from the Clarence River, are met by the annelid beds from the north-east, striking nearly at right angles to the first-mentioned rocks, both dipping at high angles, Two miles down the Clarence River, from the northern foot of Jollie's Pass, the annelid beds are definite in character, and at once assume a considerable breadth of exposure, their western boundary striking along the range between the Acheron and Alma Rivers, while the eastern boundary has not yet been determined.

Whether the annelid beds form any part of the Looker-on Mountains, between the lower Clarence and the coast-line, or their prolongation to the south-west in the direction of the Hurunui Plain, is as yet unknown. But to the annelid beds I refer the south-western part of the inland Kaikoura chain, from the point where it is broken through by or terminated by the valley of the Clarence north-east as far as the boundary of the district, as already bounded in the first part of this report. It is true that I did not succeed in verifying this opinion further than by the recognition of very similar lithological characters when compared with the rocks of the Ashley Gorge and elsewhere; but as far as this will warrant me, aided by the relative position of the rocks to a series of known age lying to the westward, I have every faith in the determination. Their exposure here reaches a breadth of some ten or twelve miles, the strata rising into and forming the greater part of the principal mountain chain in the South Island that is not in direct connection with the principal watershed of the country forming the Southern Alps, and their continuation to the north-east gives to this development of the annelid beds an importance worthy of a distinct and well-marked formation.

In the mountainous country which intervenes between those outcrops of the annelid beds already described and the main watershed of the island there is no evidence of their presence—if the fossil be required to prove this—north of the Rakaia Valley. Yet rocks not unlike them in character are found west of the Cass River, between there and Arthur's Pass. These, and their relations to the other divisions of the Maitai series, have already been treated of, and, whatever the actual position of the beds may prove to be, these do not require to be again noticed in this place.

Passing over the saddle in the range at Arthur's Pass, and following down the gorge of the Otira River, the strata, although not continually so in the main, are found dipping to the south-east. Gritty sandstones on the Pass, and down the greater part of the gorge to the westward, are seen to be interstratified with beds of a slaty character, the actual age and relations of which have not been determined, but to which, from the characters of the rock, I am inclined to ascribe a Permian age. From beneath these, resting yet further to the westward on the pale-green silky slates of the middle division of the Maitai series, appear the annelid beds. These have a considerable development in the mountains forming the southern end of the Taipo Range, and there consist of dark-coloured sandy shales and slates in which the annelid is present. Their development to the south-west has not been proved by actual observation of the rocks *in situ;* but, as shown by the frequent occurrence of the fossil in the gold drifts and older alluviums of the West Coast, the beds must be developed to a considerable extent in such positions as to be within reach of the denuding agencies which convey the materials removed from the higher ranges to the west coast of the Island.

Taken together, the evidences bearing upon this subject point clearly to a large development of these beds stretching along the higher part of the Southern Alps, from the northern boundary of Westland to the western sources of the Waitaki River.

Sections and Lithological Characters.

In describing the lithological character of the annelid beds, and the sequence and dip of such sections as may be selected for this purpose, by preference localities will be selected where the fossil itself is found.

The rocks there seen in section comprise the dark slates and sandy shales which almost exclusively everywhere contain the fossil, and which appear to be the highest beds as far as the sequence has yet been followed. Beneath these to the south-east are hard gritty sandstones, underlaid by conglomerates. The dip in this section is to the north-west at moderate angles ranging from 30 to 45 degrees. This section was but glanced at while engaged collecting from younger rocks at this place, at which time I was inclined to refer the conglomerates and sandstones to the fern beds of the Clent Hills. In the gorge of the creek at Redcliffe, the slates and sandstones seemed to form an anticline, but the general north-west dip of the strata further down the river convinces me that this does not affect the sequence as here given. The Palmer Range to the north-west must show a large development of these beds, but there is every probability of younger rocks belonging to the Clent Hills series being present. In the direction of Mount Hutt a considerable distance intervenes before rocks of a markedly different character make their appearance; but the quartzites so strongly developed in that mountain appear to underlie the annelid beds.

At Gorge Hill, on the Waimakariri River, the section there exposed consists of dark "siliceous slates" (Haast), harder and less liable to weather into shaly concretionary nodules than is frequently the case. These form the lower beds of the section as seen on the south bank of the river. Hard sandstones, varying from moderately fine to gritty, alternate with slates in the higher part of the section. These sandstones are of a yellowish-brown colour, and, where seen on the slopes of the hill on the north side of the river, are not unlike the sandstones of the Cairn Range, Malvern Hills, or the Mataura sandstones under like conditions. The dip is here, as at Redcliffe, to the westward. The total thickness of beds exposed is inconsiderable, perhaps 300 feet.

At Ashley Gorge the rocks are conglomerates, sandstones, slaty sandstones, slates, and sandy shales, yielding rapidly before the weather. Besides these, which, with one or other predominating, are the characteristic rocks of the beds, everywhere there is a remarkable rock not elsewhere seen. This, as an intensely black, lustrous, indurated shale, having a sub-serpentinous appearance, shows as the last rock seen in the banks of the river before the adjoining plains are reached.

The conglomerates, according to their strike where seen, are a yet lower rock, while these themselves are not the lowest rocks of the section.

However, it would be rash to pronounce definitely upon the sequence of the different rocks seen in this section, as the whole strata are so contorted and disturbed that, except a general dip to the north-west is observable, the section is obscure and a difficult one.

In the valley of the Clarence River, between Jollie's Pass and the junction of the Acheron River, the annelid beds present characters very similar to those at Gorge Hill, on the Waimakariri, more especially as concerns the sandstone members of this division of the Maitai series.

At the crossing of the Clarence, near the junction of the Acheron River, coming from the north, dark shaly or sandy slates form high cliffs on the left bank of the river, standing at high angles and dipping irregularly. These beds rapidly break up into slaty shingle, in much of which minute and obscure traces of plants are to be found. No annelids were observed, although this rock was exactly the material in which they are to be found.

On entering the narrow valley of the Acheron River, the rocks are indurated sandstones, with a predominance of dark sandy or slaty shales, which latter are highly contorted, but, with the sandstones generally, show an easterly dip. These rocks agree very closely in character with those seen at Ashley Gorge.

As was observed by Professor Hutton much further to the west, in the Spencer Mountains, so here the sandstones exhibit, in a far less degree than do the slates and thinner-bedded strata, the contortions, often very fantastic, into which the beds have been bent.

Having already disposed of the beds in the Upper Waimakariri, between the Cass River and the Bealey, as belonging to a lower division of this series, I would simply add that, unless a line of fault runs north and south along this part of the district in accordance with the other explanation given, the annelid beds should appear on the south-east of Arthur's Pass, with a dip to the westward. Be this as it may, on crossing the water-shed into the valley of the Teremakau, in the lower part of the Otira Gorge, we find the annelid beds presenting their usual characteristics as dark-coloured slates and sandy shales, with beds of sandstone.

The rocks here dip to the south-east, and, as I believe, are overlaid by younger Permian rocks showing in the syncline at Arthur's Pass. Downwards in the section they rest conformably on the Maitai slates.

Relations to the Beds upon which they rest.

The annelid beds on the west side of the main chain rest conformably upon the lower beds included in the Maitai series; the lower beds of the series, as far as known, resting unconformably upon other strata. In the Rakaia Valley, between Redcliffe and the south-eastern slopes of Mount Hutt, the annelid beds would appear to rest upon the quartzites and pyritous slates, which are strongly developed in the higher part of Mount Hutt, but their actual relations can only be conjectured. Possibly these Mount Hutt quartzites may belong to the Triassic series of the Malvern Hills, in which case there are no rocks older than the annelid beds exposed along the eastern border of the mountainous district of Canterbury.

However, as limestones, quartzites, and slates are developed to a considerable extent in Southern Canterbury from the Kokohu to the southern boundary of the provincial district, these apparently older quartzites of Mount Hutt may belong to this series, or Waihao formation of Dr. Von Haast, which he refers to older Palæozoic, probably Silurian, but associates with strata which in the classification of the New Zealand Geological Survey would be referred to the Upper Devonian or Te Anau formation.

Wairoa Series.

The numerous fossils collected from this formation in Nelson and in Southland have led to these being regarded as belonging to the Middle Trias formation, distinct and higher beds forming the Upper Trias in both districts. Although in this district the evidence of the age and identity of these beds is complete in certain clear sections, where some members of the series are found fossiliferous, there is yet a considerable difficulty in determining how far apparently-associated strata are to be regarded as belonging to the same formation. For, if all the rocks which are seen underlying the fossiliferous horizons alluded to are included with the Middle and Lower Trias rocks, the Kaihiku series, belonging to the Permian period, must be considered as wholly absent from any part of this district, a conclusion for which there is no warrant, further than that this has not yet been proved to be present within the district.

Nevertheless, at no great distance to the south-west, Permian rocks are well developed in the ranges between the Upper Ashburton and Rangitata Rivers; and the same rocks are not wanting in the northern part of the Island, near Nelson. In the latter place but a small outcrop of Permian rocks is at present known;

but, from the great similarity of the rocks composing it to those of the Kaihiku series, as developed in the Hokanui Hills, Southland (the resemblance being much closer than between them and the Rangitata rocks), it may be reasonably presumed that the formation was once wide-spread over the intervening area, and is yet present in many localities. But as the Permian rocks in the Rangitata have a resemblance to the annelid beds and the shaly slates underlying the diabases, cherts, &c., which latter form the upper and fossiliferous part of the Wairoa series in this district, the resemblance of the underlying part of the series to the other rocks mentioned makes discrimination between them difficult.

Further, when we admit that in the southern part of the Island there is no marked stratigraphical unconformity between the Permian and Triassic rocks, and that such is not to be detected in the Rangitata Valley, it follows that the Permian rocks have not been greatly disturbed or denuded during the intervening period—at least in such a manner as to produce a high unconformity between them and the succeeding Triassic rocks.

Thus, when treating of the Wairoa series, it must be understood that with it are included possible developments of Permian strata, which our present knowledge of the beds has not enabled me to distinguish.

The presence of Triassic and Jurassic rocks in the Malvern Hills and elsewhere was pointed out by Dr. Hector in 1869;* and subsequently Captain Hutton made a first attempt to map in the relative boundaries of the formations in the district.† But this and later attempts to subdivide this great series of formations have not been favourably received by a recent writer on the geology of Canterbury, who deprecates such attempts at the present time and in the absence of reliable information upon the subject; but, having to his own satisfaction "proved convincingly that such divisions were based upon erroneous observations and deductions," the whole are again comfortably brought together under the denomination of "the Mount Torlesse formation," "reaching in some instances from the East Coast to within twenty miles of the West Coast, and by which more than half of the Province of Canterbury is covered" (Von Haast, *loc. cit.*, p. 266). This is, however, qualified by the statement that "It is very possible, and even more than probable"—in other words, it is certain—"that this huge assemblage of beds by which it [the Mount Torlesse formation] is formed may belong to several distinct periods, ranging from Palæozoic to Lower Mesozoic" (*loc. cit.*, p. 279). I cannot but think that the knowledge which rendered clear the errors of former observers should also have been sufficient to subdivide the rocks into such groups as would have been an improvement upon former classifications, and also have obviated the necessity I am under of

* New Zealand Geological Reports, 1868, p. 45.
† New Zealand Geological Reports, 1873, p. 30.

again separating the Mount Torlesse group, and this time into a greater number of formations than before.

Extent and Character of the Strata.

Beds belonging to this formation commence in the Malvern Hills to the north-west of the porphyritic zone, and form in part the Four Points Range and Frank's Knob; and this or another line of exposure is from the Kowhai Coal-mine continued in a westerly direction. But these are unimportant compared with that which lies to the west and north. In this direction the whole of the northern end of the Mount Torlesse Range may be considered as belonging to Trias and younger formations which, from the higher peaks of Mount Torlesse, stretch down the valley of the Kowhai to the foot of Porter's Pass. From the higher part of Mount Torlesse the boundary strikes north-west across the Trelissic Basin, forming the Craigieburn Range, as far as the Cass River. South and west of this line the country was not examined, but there is a high probability of beds younger than these being present in that direction. I have been informed that fossil ferns resembling those from the Clent Hills are found on the Rakaia watershed in some of the creeks leading into the Harper River.

Except where obscured by younger strata, most of the south side of the Waimakariri Valley is formed of these beds as far as the mouth of the Cass. On the north side of the river from the rocks east of the middle part of the Poulter, or say from a line drawn from the junction of the Cass to Lake Sumner on the Hurunui River, is a wide stretch of country southward to Mount Oxford and eastward to Mount Grey which has, as far as I can make out, neither annelid beds nor Maitai slates within it. Younger rocks yet to be spoken of are present to a considerable extent, so that it must not be understood that the whole of this country is to be regarded as occupied by Trias and Permian rocks.

North of the Hurunui River, the mountains between that river and the Waiau-ua Valley largely belong to this formation, subject to like qualifications as stipulated for the district between the Hurunui and the Waimakariri.

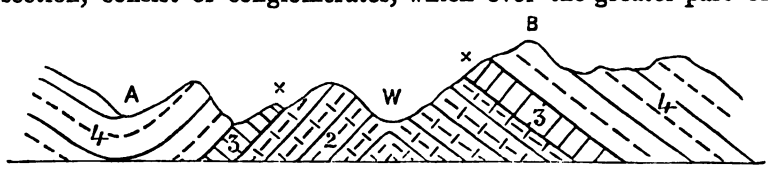
North of the Hanmer Plains, most of the country west of the Acheron River, as far as the higher eastern slopes of the Spencer Mountains, can, in the present state of our knowledge, be regarded as belonging to no other formation than this.

This statement, like the two former, is subject to exceptions which will be treated of under heading of the succeeding formations yet to be dealt with.

As the mapping of such an extent of highly mountainous country was within the time devoted to its examination an impossibility, in attempting to determine the area of this formation not more could be done than to trace the outcrop of some one of the more prominent beds belonging to it. Fortunately the diabases, cherts, and limestones of the Malvern Hills for this purpose served admirably. Therefore, at the risk of repeating in part what has already been said, it may be advisable to trace these outcrops marking the upward boundary of the Wairoa series.

As has already been stated, the diabases form the highest beds of the Wairoa series in this district, and in the outset it may be as well to give proof of this assertion. This consists in the presence in both the diabasic ash and the associated limestones of the fossil shells *Monotis salinaria* and *Mytilus problematicus*, which are everywhere only present in the highest beds of the Wairoa formation, and are strictly confined to this, not entering into the overlying Otapiri series. These fossils are found in the Upper Okuku Valley in immense numbers in a limestone associated with cherts, crystalline, and amygdaloidal rocks, with a profusion of red and green diabase ash beds.

The associated underlying rocks, as shown in the accompanying section, consist of conglomerates, which over the greater part of



Section (1)—Block Hill to Okuku Range, Upper Okuku River. 2. Lower Trias. 3. Middle Trias (diabases with *Monotis*). 4. Upper Trias, Lias, &c. A. Okuku River. B. Okuku Range. W. Waipara River. × Fossils (*Mytilus, Monotis*, &c.).

the district are mainly composed of sandstones; but in the Okuku Range other rocks are present. These are crystalline granitic rocks, as syenites and porphyries, and in this respect the conglomerates here approach in character those seen in connection with the Wairoa series, near Nelson.

The other rocks are hard sandstones of various grain, generally of a grey colour, interstratified with which are slaty shales and bands of red slate, these latter differing greatly in their relative importance as members of the series in different localities.

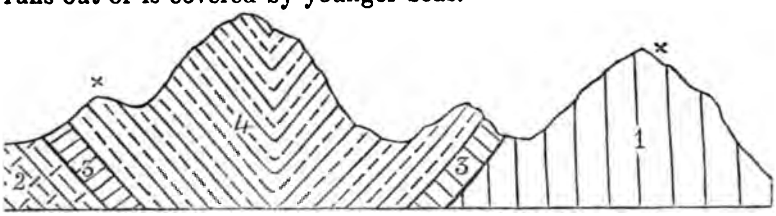
Sometimes the finer-grained slaty beds predominate, and the beds then assume the characters of the annelid beds; but they may still be distinguished, as they are not so contorted nor yet stand at such high angles as the annelid beds generally do.

I have already pointed out the position of the diabases in the Malvern Hills. The accompanying rocks agree with the general characters of the underlying beds already given.

Diabases and limestones strike westward from the higher part of the Mount Torlesse Range, along the range bounding the Trelissic Basin to the north-east, and are seen crossing the road to the West Coast, close to Craigieburn home station. The materials in the creek show them present in the higher part of the

Craigieburn Range, striking in the direction of the upper part of the Cass River. Here they suddenly terminate, the north-and-south extension of the Maitai rocks cutting them off. Commencing near the crossing of the Cass River, a line of diabasic rocks strikes eastward, parallel to that just described, the rocks between evidently forming a syncline. From this it would appear that the Waimakariri runs either on the southern side of a broad low anticline, or, if this is not the case, two or more narrower folds intervene between that river and the east-and-west line striking across the upper part of the Ashley River, where the diabases with their associated rocks are seen striking east and west, and dipping north.

Along the western borders of the annelid beds, from Oxford to the Glentui Creek, the cherts appear in the open patches of Oxford Bush, and, thence striking across the Ashley Gorge, are strongly developed as diabases in the upper part of Glentui Creek. North-east, in the direction of Mount Thomas, this line probably runs out or is covered by younger beds.



Section (2)—From Glentui Gorge across Mount Thomas Range. 1. Annelid beds. 2. Lower Trias. 3. Middle Trias (diabases, with *Monotis*). 4. Upper Trias, &c. (×) Fossils (*Trigonia*, plants, &c). × Fossils (annelids).

The greater part of the western end of Mount Thomas Range, shown in Section (2), is composed of overlying strata, and the cherts are not seen till the lower slopes of the range on the northern side are reached. From Wharfdale these strike through the ranges so as to reach the Okuku about the middle part of the lower gorge, whence the line bends more to the east, and terminates near the White Rock Station, overlaid by recent gravels or Cretaceo-Tertiary beds.

From about the same point whence the chert and diabase belt bends to the eastward in the Okuku Gorge, another line of outcrop runs to the north-west, along the Okuku Range. This second outcrop along the north-west and south-east flanks of the Mount Thomas Range, dipping inwards towards the centre of the range, and thus tied, as it were, by another line running across the north-eastern extension of the outcrop on the north-west side of the range, appears very puzzling. But so the fact is, and this can only be explained by having recourse to the hypothesis put forward in the remarks on the general geological structure of the district—namely, that anticlines of these younger beds have been acted upon by movements acting at right angles to those which originally threw them into north-west and south-east folds. Be this as it may, the line last mentioned runs along the Okuku Range to the Waipara Pass, leading from the Upper South Waipara into the Upper Okuku Valley.

Stretching across the pass to near the source of this branch of the Waipara, the diabases and cherts turn sharply to the west, and strike in that direction across the ranges towards the source of the main branch of the Ashley River. The Ashley was not followed up so as to ascertain at what point the diabase beds cross the range intervening between that and the Esk River, but of their being so continued there can be little doubt, as the syenitic rocks which occur with the diabases are more than usually plentiful in the main stream of the river as it leaves the gorge and enters upon the Upper Ashley Plains.

It would be vain to speculate how far this is extended westward, and whether it ends abruptly against the Maitai slates in this direction or turns to the north, as there is some reason to believe it does. But, having lost this, a fresh line must be taken up: the last, striking east and west, was found to dip to the north, and consequently rocks younger than Middle Trias must lie between it and the Hurunui River. But before reaching this river the strike and dip again change, but still we have the diabases and cherts dipping to the westward and stretching along the ranges behind Heathstock and the Horsley Downs. These lead us beyond the confines of Canterbury, before leaving which a few more outcrops have to be noticed. One of these lies on the north-west side of the Mount Hamilton Range, separating the basin of the Middle Waipara from the low land between that range and Heathstock. Another occurs on the saddle leading from the Omeo Valley on to Cabbage-Tree Flat and the Greta Creek, leading to the Hurunui River, on the road from Glenmark to Cheviot Hills. In the same district the cherts are well developed in the Black Hills, forming the watershed between the Omeo Creek and the Motunau River. Both of these outcrops are of considerable interest, as they lie to the eastward of the theoretical extension of the annelid beds from the Ashley Gorge, which should pass through the Weka Pass north-east across the Hurunui Plains, so as to be in a line with the south-west extension of the inland Kaikoura chain.

Between the upper parts of the Hurunui and Waiau-ua Rivers the diabases are present, and should be so in at least two distinct lines, striking in a generally north-east and south-west direction; but, further than that they strike in this direction from Canterbury, and are continued in the same general direction in the district immediately north of the Hanmer Plains, I have, from actual observation, no knowledge of their presence in the mountains between the Hurunui and the Waiau-ua.

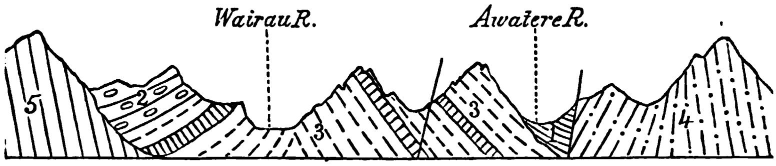
A great development of chertose rock is present in the range dividing the Hanmer Plains from the Clarence Valley so as to occupy the whole range between Jollie's and Jack's Pass. From the left bank of the Clarence River these rocks strike to the north-east along the higher western slopes of the range between the Acheron and Alma Rivers. In the northern part of this range the cherts change to diabasic ash of a highly calcareous character, many of the agglomerated blocks of this rock being full of calc-spar crystals and masses of subcrystalline limestone. This line carried to the north-east should cross the Acheron River below the point where that is joined by the Alma, but appears to die out before reaching so far. Younger rocks developed to the west-ward may to the north-east and in the Upper Awatere hide the extension of this line. The general dip along this line of chert and diabasic rocks between Jack's Pass and the junction of the Alma with the Acheron must be to the westward, although at Jack's Pass it is more to the south, while near the junction of the Alma the dip in what I take to be the associated beds is at high angles to the eastward. There cannot be a doubt but that these beds are younger than the annelid beds adjoining to the east-ward, nor that there is unconformity between the two. A corresponding outcrop of cherts and diabases in the mountains to the north-west of this line shows that these form the two sides of a syncline filled with younger rocks yet to be spoken of.

Commencing in the ranges between the Wairau and Awatere Valleys, and within the watershed of the latter, diabases, limestones, and cherts strike to the south-west. These reach the west side of the Wairau Valley six miles below the junction of the Rainbow with the Wairau River. At this place the beds are striking south, and have a very high dip to the west. They are traceable up the Wairau Valley to the junction of the Rainbow with the main stream. This line then strikes across the ranges at the source of the Wairau River, and, by report, appears in the Henry and Ann Rivers, both tributaries of the Upper Waiau-ua. The evidence of the presence of these rocks in the latter localities rests not upon the testimony of one observer only; Mr. Fowler, of Lake Guyon, and Mr. McArthur, of St. James's, Clarence River, having both observed these. As described by the latter gentleman, the rocks in this locality are red and green, with frequent masses of hard white or grey limestone, some interest being taken in the latter rock on account of the cost of quicklime, which is used to some extent in this district.

The continuation of this line further to the south-west may be considered probable; but, as before observed, the country in this direction has not been examined with this object in view, and although I made inquiries respecting such rocks I could not satisfy myself that they had actually been observed.

Returning to the Upper Wairau Valley, it has already been said that the diabases, &c., there dip at high angles to the west. They are overlaid in the mountains to the west by rocks belonging to the Otapiri series, while to the eastward grey sandstones and slates are exposed in the narrower part of the gorge as underlying rocks.

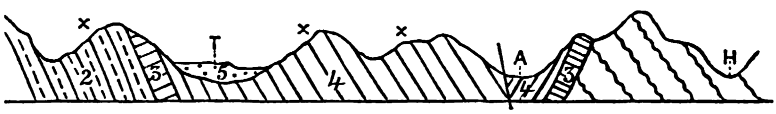
Three to four miles above the Rainbow junction, in the main branch of the Wairau, the diabases again appear, this time dipping to the eastward. Yet higher up the river, before reaching the point where the Canterbury track leaves the Wairau in the ranges to the east, the cherts are well developed, these, with the beds on the west of the Wairau Valley at the Rainbow junction, forming an anticline in the mountains to the north-east. To the



Section (3)—Across the Wairau Gorge at Rainbow junction to east side of Awatere Valley, near source of that river. 1. Middle Secondary (Liassic?). 2. Otapiri series. 3. Wairoa and Kaihiku series. 4. Annelid beds. 5. Maitai slates and sandstone.

south-west, and nearer the source of the Wairau, there has been great disturbance, and the outcrops of these rocks do not indicate the pressure of a regular anticline, but rather the "dome- and cup-shaped depressions" pointed out by Professor Hutton as characterizing the structure of the mountains further to the west.

A line of chertose rocks strikes from the Wairau River along the borders of the Tarndale Flats and the north-west side of the valley of the Alma River, as in Section (4); but further than the



Section (4)—Mountains west of Tarndale, across Alma Valley to Acheron River. 1. Annelid beds. 2. Lower Trias. 3. Middle Trias (diabases with *Monotis*). 4. Upper Trias, Lias, &c. 5. Recent or Pleistocene. T. Tarndale Flats. A. Alma River. H. Acheron River. × Fossil plants.

immediate vicinity of Tarndale this has not been traced. There is, however, a probability that this line, which dips to the east, and that which runs along the range between the Alma and the Acheron, converge so as to form the great development of cherts seen at Jack's Pass.

In tracing the different lines followed by these rocks it cannot but be apparent that these, with their associated strata, form no inconsiderable portion of the district lying east of the main chain of mountains. To give a satisfactory account of this formation as so developed in this district cannot be the result of a few weeks' labour, nor yet given within the limits of this report. At present nothing more can be done than to give the details of one or two sections in which the rocks underlying the diabases clearly belong to the same series. In the Okuku Range the cherts and diabases are strongly developed, and underlaid by sandstones containing between them beds of slaty shales, and at times a ferruginous chert which contains a small percentage of gold. As shown by an analysis made in the Colonial Laboratory a specimen of this rock yielded 4 dwt. to the ton. Slaty shales and conglomerates containing granitic rocks underlie the whole, being underlaid by an undetermined thickness of sandstones and slates, with obscure remains of plants. Red slates are on the spurs of Black Hill interstratified with these beds.

In the section across the Mount Thomas Range, from the gorge of the Glentui Creek to Wharfdale, there is not an equal thickness of strata between the diabases and the annelid beds, the most noticeable rock being a grey sandstone with white powdery joints, identical with that seen at the upper end of the Wairoa Gorge, which latter has been in other respects compared with a similar rock in the Clent Hills.

At Tarndale, where the rocks are in the hills behind the home station dipping to the east after passing the cherts, &c., the rocks are coarse gritty sandstones, with beds of black indurated shale. The sandstones often contain indistinct plant-remains. These rocks closely resemble those seen on the east slope of the range at Porter's Pass, on the West Coast Road, Canterbury, which also contain numerous broken plant-remains. Farther back in the ranges behind Tarndale dark shales cover the sides of the mountains with shingle, the coarser hard sandstones not being so abundant in this direction, this part of the section agreeing with the lower rocks seen in Lee's Valley. In the Okuku Valley black shales underlying the diabases have a nodular structure, which is also seen in the rocks occupying the same position in the Upper Wairau at the Rainbow junction. The other rocks in the latter section have already been alluded to.

With the diabases in the Wairau River are numerous examples of amygdaloidal, the base of which is a brown or dark red rock, the cavities always small and circular, being filled with a white mineral. The same rock is abundant in the Waipara, Okuku, and Ashley Rivers, occurring as boulder masses in the diabasic tufa or ash between the Upper Okuku Gorge and the Waipara Pass.

Proofs of the age of these rocks need not again be given, the fossil shells already named being sufficient. These are in places associated with obscure corals, which are found in the section of the same beds at Wairoa Gorge. The relation of the beds to the underlying annelid beds may also without comment be accepted as that of highly unconformable strata; the abrupt manner in which the diabases are terminated against the Maitai rocks west of the Cass River showing this, further proofs of which may be seen in the Clarence Valley, between the cherts of the Wairoa series and the annelid beds themselves.

OTAPIRI SERIES, BASTION SERIES, AND PUTUTAKA FORMATION.

These three groups of strata have to be taken together, as at many places it was impossible to say to which series the beds present belonged. It is not supposed that there is any very marked unconformity between the Bastion and Pututaka formations, while the Otapiri is everywhere known to follow the Wairoa beds conformably.

The beds forming the Cairn Range, in the Malvern Hills, and thence striking across Knight's Flat to the eastern base of Four-Points Range, must, in consideration of the fossils obtained from them, be considered as belonging to the youngest of the three. The fern-beds in the Malvern Hills are said by Professor Von Haast to underlie the diabases, cherts, and limestones of his Mount Torlesse (Carboniferous) formation, but which have been proved to be of Triassic age. This they may appear to do, but it cannot be conceded that this is their true relationship. The beds are highly disturbed in the Cairn Range, and the stratification is by no means regular, but the dip is fairly pronounced in an easterly direction, and where the beds last crop out, east of Hart's coal mine, there is no evidence of their making an anticline so as to pass under the Triassic rocks of Frank's Knob, and the section has to be strained to make it appear as though they did.* The most reasonable interpretation of this section is to take it as it appears, and show the beds as unconformable to the older ones farther to the west.

In the Mount Thomas Range, the beds overlying the cherts forming the highest beds of the Wairoa series are grey slaty shales, with coarse grey sandstones, in which latter coaly matter and coarse impressions of plants are freely included. These beds represent the Otapiri series, and have associated with them crystalline rocks as dykes. On the west side of the range near Wharfdale I found numerous indistinct impressions of plants in these beds; also a fossil shell. This shell, a *Trigonia,* is confined to the Otapiri and Wairoa series at Nugget Point, in the Hokanui Hills, and at the Wairoa Gorge. The cherts limiting the Wairoa series upwards, this shell indicates the age of the beds in which it occurs as Upper Trias, or belonging to the Otapiri series. Overlying this horizon there is, in the same range, a considerable thickness of strata included in the syncline containing the diabases in the upper part of the Glentui Creek and the cherts at Wharfdale, the higher beds of which strata resemble very much the Mataura sandstones. These extend south-west across the upper end of the Ashley to Mount Oxford, as shown by the direction of the diabasic outcrops, and must, with the Otapiri series, be largely developed north and east of Mount Torlesse. In the Mount Thomas Range the same beds probably reach as far to the north-east as the Okuku

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* Haast, *loc. cit.*, Sec. 1, Plate II.

Gorge. Near the sources of the Okuku River the same beds are largely developed, and spread over a considerable breadth of country between there and the Hurunui River. They also form the north-east slopes of the Okuku Range, and a considerable part of the range separating the Hurunui Plains from the Waikari Valley. As seen near the Hurunui Bridge, the sandstones, &c., closely resemble the Mataura series in Southland.

The Leslie Peaks, north-east of the Waiau-ua Gorge, probably include all three formations included under the present heading; but the hills bounding the north-east corner of the Hanmer Plains belong to the youngest of the three formations so included. On ascending the range leading from the Hanmer Plains across Jollie's Pass the rocks seen in every way resemble the Mataura sandstones, and at frequent intervals contain plant-beds. Good specimens are however rare, a fragment of a *Tæniopteris* being the only recognizable plant collected.

The valley of the Alma River has within it a considerable development of these higher beds. There the Otapiri beds are considerably indurated, and often closely resemble those of the Wairoa series. On the west side of the syncline which they here form, the Otupiri beds are overlaid apparently conformably by younger and less indurated beds as sandstones and black shales, which in many places are full of plants; but, as at Jollie's Pass, the only recognizable form is a species of *Tæniopteris*. These beds between the Alma and the upper part of the Acheron River form an isolated block of mountains separated from the ranges to the west by the Tarndale Flats. The lower country forming the saddle leading from the upper part of the Acheron into the Upper Awatere is also a continuation of these same beds.

At its junction with the Wairau and for some distance up the Rainbow River the rocks belong to the Otapiri series, as shown by their position in relation to the diabases. They are also much less indurated than the beds below the diabasic cherts, and contain the usual abundance of broken plants.

Scattered over so wide an area, all these localities could only be glanced at for the purpose of determining the position of the beds as groups of strata; so that, though this district has not yielded fossils as richly as many other districts have done, on closer examination it is probable that fossils will be found in sufficient abundance satisfactorily to determine the age of the beds.

OTAPIRI SERIES, BASTION

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...ALEY COUNTY.

...seam of coal lately (as
...the upper part of the
...north-eastern part of Canter-
...Wellington on the 23rd of January
...examining the locality.

Coal.

...examination did not prove a discovery
...it might. A small seam of coal
...inches thick, of which not more than a foot
...of fair quality, was shown me. This seam is
...part of Boundary Creek, and lies to the north-
...range between Motunau and Stonyhurst.
...same neighbourhood were examined, but the
...less encouraging in these than in the first-
examined locality.

While I am thus compelled to speak discouragingly of the seam
of coal which I examined, I wish to explain that—the outcrops
being placed near the western limit of the formation in which it is
found, and not far from a transverse outcrop of old rock dividing
the two basins the lower beds of the Cretaceo-Tertiary series in
which formation the coal occurs—these thin seams are no criterion
by which to prejudge the capabilities of other seams, or the same
seams in another part of the district. Probably nearer Stonyhurst,
or more to the north-east, better seams will be found; but these
must be looked for along the outcrop of the coal measures west of
the limestone ridge, as the overlying rocks are of great thickness,
and the dip, though not more than 20 to 30 degrees, soon carries the
coal beyond the reach of such workings as would prove practicable
without shafts being sunk, and constant work carried on.

Although the seam examined proved so thin, the rocks imme-
diately underlying it to the westward were not so clearly exposed
... but that another and better seam might be found. A considerable
thickness of black coaly shale forms the lower beds of the series,
which, if followed to the dip, might change into a coal seam.

South-west of this point a ridge of Triassic rocks divides this
coal in Boundary Creek from that cropping out in the upper
Motunau River, which latter is sufficiently thick to be of some
practical value, and is at times worked for local consumption.

The coal-beds in the upper part of the Motunau River were
examined by Mr. Buchanan during the early part of 1867; and,
as his remarks thereon were printed in a now scarce report, I may

uote such parts of that report as relate to the present ct :—

"It is only to the south of the Hurunui River that the brown-al formation assumes any importance. At Motunau Creek the eds extend four miles from the sea.

"Coal is reported to have been found at Stonyhurst, and such may probably be the case, but the Motunau basin is entirely cut off from any that may be there by a ridge of Primary hills.

"On one of the branches of Motunau Creek, close to the base of the Black Hills, an outcrop of coal is seen in the bed of the creek. It dips south-east 15 to 20 degrees. On sinking a hole the seam was proved to be three feet thick. The hole was sunk one foot further into a whitish-grey clay, but imperfect tools and water prevented anything further being done. The same seam lower down the creek is a superior coal, burning with a clear, bright flame, and easily ignited. It seems to be a coal well adapted for the manufacture of gas."

In a footnote: "This coal, on being examined in the Laboratory of the Geological Department, gave the following results: *Common brown coal* of the same character as that at Kowhai and Big Ben Mines. Powder, black; ash, red; coke unchanged. Water, 18·15; fixed carbon, 40·37; hydro-carbon, 36·11; ash, 5·37."

At the time when this analysis was made it was not understood that the Motunau coal was of the same age as that of the Kowhai and Big Ben Mines, but it was considered by Mr. Buchanan to be of old Tertiary age; but in the same year (1867) Dr. Hector examined the district, and referred these strata to the Cretaceous formation.*

As late as 1873 Captain (Professor) Hutton considered these Motunau coal-beds as belonging to the Parcora formation—Upper Miocene—of his report on the North-east District of the South Island. It however turns out that Dr. Hector was correct in referring these coal-beds to the lower part of the Cretaceo-Tertiary series, as they are overlaid by sands containing specimens of *Plesiosaurus* and *Mauisaurus* of the same species as are found at Amuri Bluff and in the Middle Waipara.

Geology of the District.

The following notes relating to the country between the lower part of the Waipara Biver and Motunau are not intended to do more than give a general outline of the geology of the district. Perhaps it had been wiser to have allowed these remarks to stand over for a time, till a more detailed examination should be made; but, having made some observations of importance bearing on the relations of the Cretaceo-Tertiary series, and wishing to record these, at the risk of some inaccuracies I have thought it best that these notes should take the form of a report.

* Progress Report, 1868, p. xii.

The following is a table of the different formations occurring within the district:—

Table of Formations.

Age.	Formation.	Character of Strata.
III. Upper Miocene	Motunau beds ...	Sands and sandy clay, with bands of cement stone.
IV. Lower Miocene	Pareora beds ...	Grey sandy beds.
V. Upper Eocene	Mount Brown beds	Coarse shelly limestone, with marly beds.
VI. Cretaceo-Tertiary	a. Grey marls ...	Marly sandy beds, with sandstone bands.
	c. Fucoidal greensands	Chalky marls.
	d. Amuri limestone	White fine-grained limestone.
	e. { Teredo limestone	Banded calcareous greensands.
	e. { Marly greensands	Grey sands.
	f. Island sandstone	Grey sands, with large concretions.
	g. Coal-beds ...	Soft sandstones and coaly shales, with coal.
X. Middle Trias...	Wairoa series ...	Diabase ash, cherts, sandstone, shales, &c.

There are heavy beds of Pleistocene age filling the lower part of the Omeo Valley, showing as fine silts overlaid by false-bedded sands. These are not included in the above table, as they scarcely belong to this, but rather to the Weka Pass district. The superficial Pleistocene gravels and sands of Motunau have also been excluded. These latter are best exposed along the high sea-cliffs which line the shore from Motunau to Stonyhurst. On the terraces these beds are gravels giving no evidence of a marine origin. Further than noticing that traces of these gravels are to be found on the coast range at a height of 300 feet above the sea, I paid little attention to these beds.

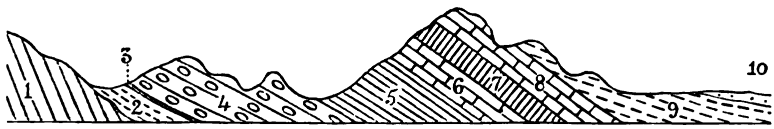
FORMATION III.—UPPER MIOCENE.

Motunau Beds.

These beds, as blue sandy clays with lenticular concretions, are exposed along the coast from a little south-west of Motunau to Stonyhurst, and underlie the gravels of the lower terrace lands. The beds have a low dip in a south-east direction, and the fine-grained cement stones in many places are full of fossil shells. The Motunau River, and three lesser creeks between Motunau and Stonyhurst, have cut deeply into these beds, and show in high cliffs exposed in this manner the general character of the strata, while the streams themselves are full of fossiliferous concretions washed out of the softer beds. These were collected from by Mr. Buchanan in 1867, and a list of the fossils is given in the Geological Reports, 1872–73, p. 51. This horizon is, in the last Geological Survey classification, reckoned younger than the Lower Miocene or

Pareora formation, and in accordance with this arrangement they have been placed in the above table as Upper Miocene.

As seen in Boundary Creek—Section (1)—(the second north of



Section (1)—From the source of Boundary Creek across Mount Friday to the sea: three and a half miles north of Motunau. 1. Middle Trias (diabases). 2. Coal-beds. 3. Coal. 4. Saurian beds. 5. Grey sands. 6. Amuri limestone. 7. Grey marls. 8. Mount Brown limestone. 9. Pareora series. 10. Recent.

Motunau), an unconformity separates the Motunau beds from an underlying series of sands, which in character much resemble the Pareora beds.

Formation IV.—Lower Miocene.

Pareora Beds.

These beds, as developed within this district, are not fossiliferous on the south-east side of the coast range, and are distinguished from the preceding only by a slightly coarser variety of the sandy beds, and the absence of concretions in the beds. The beds here described as belonging to the Pareora formation may really represent the grey marls, but the absence in the Boundary Creek section of the other members intervening between the Pareora beds and the Amuri limestone somewhat favours their being placed as above.

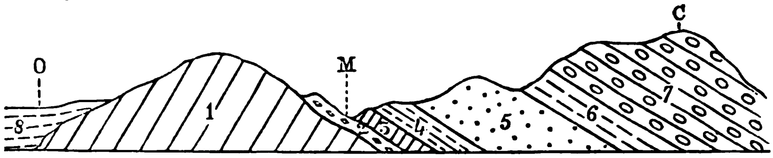
North of Boundary Creek the beds rapidly thin out, or are overlaid by younger strata. To the south they rise into and form the eastern slopes of the coast range of hills north of the Motunau River.

Where the Motunau River breaks through the coast range the relation of these beds to the underlying strata can be studied more advantageously than in Boundary Creek, the section being in the former locality directly across the strike of the beds, which is not its direction in the latter.

Formation V.—Upper Eocene.

Mount Brown Beds.

These rocks consist of coarse shelly limestones, similar to those of the same age in the Middle Waipara and Weka Pass sections. In places they are interbedded with marly clays. They appear to be strongly developed on the northern end of the Mount Cass Range, where they are separated from the Amuri limestone by the grey marls. On the Motunau Road leading from the Omeo Valley eastward—see Section (2)—past the north end of this



Section (2)—From Omeo Valley to north end of Mount Cass Range. 1. Otapiri series. 2. Ostrea beds. 3. Grey sands and shales. 4. Loose grey sands. 5. Sands. 6. Shales. 7. Saurian beds. 8. Recent. O. Omeo Valley. M. Motunau Road. C. Mount Cass Range.

range to the coast, eight miles south-west of Motunau, quantities of this rock are seen in the creeks carried to the north from the higher part of Mount Cass Range. In the direct line followed by the road no rocks of this age are seen or appear to be present: yet half a mile north of the road-line, in the upper part of the south-west branch of the Motunau River, Mount Brown limestones are seen to overlie grey marls, and at that place form a sharp syncline, which appears to carry yet younger beds belonging to the Pareora formation. These higher beds, which are blue sandy marls, I refer to the Pareora formation on account of the presence of very large specimens of *Dentalium solidum,* which is one of the most prominent fossils of the Pareora beds, and which does not appear to be present in the Motunau beds. The Motunau beds are also wholly on the seaward slope of the coast range, which may be another means of distinguishing the two sets of beds in this district.

The Mount Brown limestone strikes north-north-east, leaving on the right hand the valley of the south-west branch of the Motanau River, but it does not appear to reach the upper part of the main branch of the river, lower Cretaceo-Tertiary rocks being developed in this direction. Consequently the area covered by this development of these beds within the upper Motunau Basin to the north of the road-line is but small.

On the coast range south-west of the mouth of the Motunau River the Mount Brown limestone forms the summit of the highest peak (1,200 feet above sea-level), and on the eastern slopes shows a high dip to the south-east. The beds are developed to some extent along the coastal slopes of this range, but do not appear in a north-east direction to cross the Motunau River, nor are they present on the coast range between the Motunau River and Boundary Creek.

North-east of the gorge of this latter creek Mount Brown beds appear for the last time in Mount Friday, situate between Boundary Creek and the next to the north-east, three miles from Stonyhurst. On Mount Friday these limestones appear only on its south-east face, never reaching the deep gorges of the creeks on either hand.

Evidently, along with the Cretaceo-Tertiary rocks, the Mount Brown beds have suffered denudation to a great extent before the deposition of the Upper Miocene Motunau beds. This is shown by the manner in which the beds appear as isolated patches between the younger Tertiary beds and the Cretaceo-Tertiary rocks.

Formation VI.—Cretaceo-Tertiary.

a. *Grey Marls.*

In the north-east part of the Mount Cass Range the strata are arranged as an anticline, striking south-west along the range towards the Waipara Gorge. To the north-west lies a syncline, in which the grey marls are seen as the next strata overlying the Amuri limestone. Where seen in the upper part of the south branch of the Motunau River the grey marls are partly overturned in their lower beds, in which condition they are seen dipping to the south-east. Nearer the centre of the syncline, which runs nearly parallel to this branch of the Motunau River, the dip is—as on this side of the syncline it should be—to the north-west. The grey marls, or beds very similar to them in character, appear on the west side of the syncline, and, as the section appears, these rest on a lower series unconformably, which latter must belong to the lower Cretaceo-Tertiary rocks, somewhere about the horizon of the coal-beds. In this part of the district the grey marls are followed by the Mount Brown bed without any apparent unconformity. The Weka Pass calcareous greensands are not present, and this might at first sight be taken to show that the grey marls are more nearly related to the Mount Brown limestones than to the Weka Pass stone. On the northern end of the coast range south-west of Motunau the grey marls intervene between the Amuri limestone and the Mount Brown beds. North-east of this point, between the Motunau River and Boundary Creek, the grey marls follow, and are interbedded with the chalky upper portion of the Amuri limestone, showing a close relationship to the Cretaceo-Tertiary rocks, which must convince any one that the conformity to the Mount Brown beds in the south-west branch of the Motunau River is only apparent. North-east of Boundary Creek the grey marls, like the Mount Brown limestone on Mount Friday, are suddenly cut off, and do not reach as far as the next creek to the north-east.

Fossils are plentiful in grey sandy beds and marly strata seen in the road cuttings on the banks of the south-west branch of the Motunau River. *Dentalium tenuis* and fine specimens of *Pecten zittelli* occur at this point. Other fossils are plentiful. In Boundary Creek the chalky beds interstratified with the sands contain a few Brachiopoda and fragments of plants, which latter have been changed to iron pyrites.

c. *Fucoidal Greensands.*

These beds, forming the upper part of the Amuri limestone, are only seen in the gorge of Boundary Creek, and elsewhere are not likely to be present except where they are protected by overlying strata.

d. *Amuri Limestone.*

This rock is largely developed on the Mount Cass Range from the northern bank of the Waipara River to the road leading from the Omeo Valley to Motunau, and thence along the coast range to the north-east bank of the Motunau River. In the higher and northern parts of the Mount Cass Range the beds form an anticline, which in the upper part of the south-west branch of the Motunau is denuded so as to expose the lower Cretaceo-Tertiary beds. On the north-west side of the denuded portion of this anticline the Amuri limestones stand at high angles, and in places are overturned so as to dip towards the axis of the anticline.

Under such circumstances their exposure is but a narrow belt, forming part of a low range between the south-west branch of the Motunau River and a creek feeding into the same from the east, and draining the coast range to the south-east of its junction. This line of Amuri limestone, like the younger rocks to the westward of it, terminates before reaching the main or north branch of the Motunau River. It does not appear to be represented on the west side of the syncline formed by the younger strata along the south-west branch of the Motunau River.

At the upper end of the lower gorge of the Motunau, where it breaks through the coast range, the Amuri limestone, as in the northern part of the coast range on the south side, lies to the westward of the watershed, and, striking more to the northward than the younger beds, appears in the upper end of the gorge of Boundary Creek at the western foot of the range. Before reaching this point it has altered its strike to a north-east direction, and again appears on the coast side of the range where last seen on the north-east slopes of Mount Friday.

In the Omeo Valley a patch of Cretaceo-Tertiary rocks appears on the south-west slopes of the Black Hills, but these were not visited. Between Mount Cass Range and the lower part of the Omeo Valley there is a lower range of hills on which the Amuri limestone dips to the north-west. This line of limestone is separated from the higher range to the south-east by a rough irregular valley, in which the underlying rocks of the same series are exposed. This western line terminates at the surface before reaching the Waipara River, but is continued below the superficial deposits of the plain westward to the point where the railway bridge crosses the Waipara River. In driving the piles for this bridge the shingle in the river-bed proved of no great depth, and the rock reached was a white fine-grained limestone, which, I was informed by some of the workmen engaged in that work, exactly resembled the limestone on the Mount Cass Range. The Amuri limestone therefore forms a syncline between the back of the Deans Range and this point. And it is curious to note that the younger Cretaceo-Tertiary and Tertiary rocks of the Deans and Weka Pass sections lie in the western side of this syncline, these showing no tendency to change their dip so as to conform to the south-east side of the syncline. The higher Cretaceo-Tertiary rocks may do this, but they are hidden from observation by younger deposits.

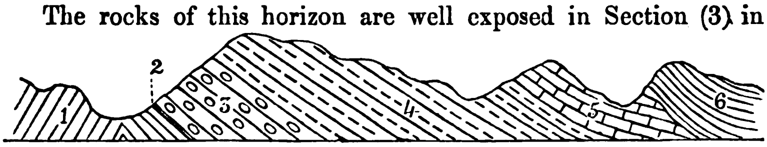
As usual, fossils are extremely rare in these rocks. Except the minute Foraminifera which form the great bulk of this rock, large and beautiful fucoid impressions were the only fossils observed. Of these latter there is an extraordinary display in large blocks of this limestone, which are present in the bed of the stream at the upper end of the gorge of Boundary Creek.

e. *Teredo Limestone.*

This rock is only seen to the north-east of Boundary Creek, and between there and Stonyhurst. It is thicker here than at the Amuri Bluff by some 50 feet; but, except that it is thinner-bedded, it differs but little from the same rock at that place. It is of some interest, as being the lowest rock of the Cretaceo-Tertiary series which is seen in contact with the unconformable younger Tertiary rocks; the older rocks, including the coal, being confined to the west side of the coast range, along which side of the range there are no Tertiary rocks north of the main branch of the Motunau River. As seen north-east of Boundary Creek, this rock flattens out so as to indicate that the lower beds of the series form a broad syncline between the coal-beds skirting the older Triassic rocks and the coast-line between Motunau and Stonyhurst. This is proved by the presence of this rock east of the coast range, that showing in the small creeks feeding from the terrace at the north-eastern base of Mount Friday into the larger creek to the north-east between there and Stonyhurst. On the northern slopes of Mount Friday these rocks are fossiliferous, but no collections were made from them, as they were rapidly passed over on the occasion of my visiting the coal seams further to the west.

e'. *Marly Greensands.*

The rocks of this horizon are well exposed in Section (3) in



Section (3)—Showing position of coal, three miles north of Motunau. 1. Middle Trias. 2. Coal. 3. Saurian beds. 4. Grey sands. 5. Amuri limestone. 6. Mount Brown and Pareora.

the deep narrow gorge of the first creek of any consequence south-west of Stonyhurst. This creek has cut through these beds to a depth of not less than 200 feet, forming a narrow channel 10 or 12 feet wide at the bottom, and in many places from the terrace on the south side to the adjoining hillside this chasm is not wider than deep. The beds of this division consist of dull grey sands or soft sandstone, and have a thickness of 200 feet to 300 feet. They stretch, from some distance north-east of the deep creek just mentioned, along the north and north-west slopes of Mount Friday, and in a south-west direction across Boundary Creek above the gorge, and may be said to be continuous in this direction along the north-west side of the coast range, till the beds disappear below the anticline formed by the Amuri limestone in the northern part of the Mount Cass Range. The total length of this exposure is about ten miles. Except for a mile or so on either side of Boundary Creek, the beds have an inconsiderable breadth of exposure, owing to their south-east dip on the north-west side of the range. The same beds are exposed on the western side of the anticline which commences on the south side of the north branch of the Motunau River; but in the south-western part of their exposure are comparatively thin, or highly inclined, their breadth of exposure being less than on the east side. These beds are present along the north-west slopes of the Mount Cass Range, being there exposed along an anticline parallel to, but different from, that which strikes south-west from the main branch of the Motunau River. Along the north-west slope of the Mount Cass Range the beds are continued till they are last seen as high cliffs on the Waipara River, above where it enters the lower gorge. Except one vertebra of *Plesiosaurus crassicostatus*, which comes either from the lowest beds of this group or from the highest of the next underlying, no other fossils were obtained from these beds.

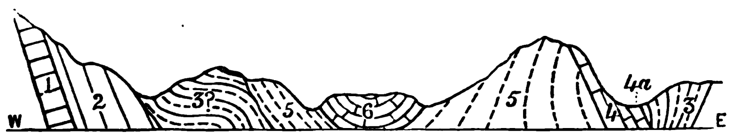
f. *Island Sandstone.*

In the upper part of Boundary Creek the country on either hand forms a kind of basin, which, although rough and broken by low hills, from its nature as much as from a less angle in the dip of the strata, admits of a greater breadth of exposure for the same thickness of strata than such would have had on the range to the eastward. In the deep creek three miles south-west of Stonyhurst these and the underlying beds are well exposed. The strata consist of grey sands dipping at moderate angles to the south-east, and contain numerous large concretions. These concretions not unfrequently include fossilized wood, and occasionally saurian remains. From one of these boulders I extracted a moderate-sized block of stone, containing eight vertebræ of *Plesiosaurus (australis ?)*, together with the ribs corresponding thereto. In two other concretions were observed vertebræ and other bones of *Mauisaurus haastii*, and from another boulder I obtained the above-mentioned vertebra of ***Plesiosaurus crassicostatus***. In the south-west branch of the Motunau River the saurian beds are well exposed on both sides of the anticlinal ridge between the two lines of Amuri limestone. Between the upper part of the Motunau River and Boundary Creek, a range of old rock causes the Cretaceo-Tertiary rocks to break into two lines, the south-east of which is continuous with the same rocks in the upper part of Boundary Creek, while the north-west side does not pass the ridge of Triassic rocks, but forms the Upper Motunau basin.

g. *Coal-Beds.*

These follow the lines of outcrop of the last-described beds. The beds are conglomerates, sandstones, and shales. In the main branch of the Motunau the coal-beds must, in their outcrop, describe a semicircle mantling round the spurs of the Triassic range dividing the Motunau watershed from that of Boundary Creek, and from the centre point of this semicircle be prolonged along the anticline already described as striking in a south-west direction. In the valley of the creek by which the road to Motunau leaves the Omeo Valley, the coal rocks are also seen lying hard on the south termination of the Black Hills, and striking parallel to the Mount Cass Range between that and the range of limestone hills bounding the lower part of the Omeo Valley on the south-east side.

Along the road cuttings leading over the saddle into the south-west branch of the Motunau the lowest rocks of the coal series are



Section (4)—Across south branch of Motunau Creek. 1. Middle Trias (diabases). 2. Otapiri series (?). 3. Coal-beds. 4. Amuri limestone. 4*a*. Oyster-beds. 5. Grey marls. 6. Mount Brown limestone.

seen as conglomerates, on which rest the black oyster beds of the Waipara and Malvern Hills. These are succeeded by loose grey or yellow sands with beds of dark or light-coloured shales, in which fossil wood but little changed is abundant. Nothing approaching the nature of coal was observed in this vicinity, but the black oyster and the direct sequence upwards from that bed to the Amuri limestone tell plainly the position of the beds at the base of the section.

Formation X.—Trias.

Wairoa Series.

With this series there are probably included much younger strata, there being rocks not unlike the Jurassic Mataura sandstones within the district. This point, in the absence of fossils, cannot be determined.

These oldest rocks of the district were first referred to the Triassic period by Dr. Hector in 1867, and the presence of chertose and diabasic rocks in the Black Hills between the upper part of the Motunau and Omeo valleys must be considered sufficient proof of the age of these rocks, as they have elsewhere yielded the characteristic fossils of the Wairoa formation.

The Black Hills, striking south-west and north-east, give off low spurs running south-south-east, which divide the lower Cretaceo-Tertiary and coal rocks into distinct areas—one within the watershed of the Omeo Valley, another in that of the Motunau River, and a third in the upper part of Boundary Creek, and thence extending along the slopes of the range in a north-east direction.

Were thick seams of coal to be discovered in this district the great length of the outcrop would admit of much coal being worked without sinking for it to any great depth. Unfortunately, along the greater part of the different outcrops the coal is either of no great thickness or absent. This is likely to be more especially the case along the westerly outcrops resting on the old rocks of the Black Hills. Most likely the coal thickens towards the dip of the beds; and, looking upon the whole field as dipping to the south-east, the most likely place where valuable seams might be found would be along the anticline between the south-west branch of the Motunau and the coast range. Along the crest of this anticline the coal rocks appear at or near the surface, but in the southern part of this line dipping at high angles.

DISTRICT WEST AND NORTH OF LAKE WAKATIPU.

REPORT BY ALEXANDER M'KAY.

HAVING received instructions directing me to employ the months of February and March in making an examination of the country to the west and north of the upper part of Lake Wakatipu, including the Lake Harris Range and the upper part of the Hollyford Valley, in compliance with these I have the honor to report as follows:—

On the 23rd of January last I left Wellington for the South Island, but was delayed in Canterbury, examining a district already reported upon,* and on this account did not reach Dunedin till the 2nd of February. On the 4th February I reached Queenstown, where necessary preparations delayed me for a few days, and I did not leave for Kinloch, at the head of Lake Wakatipu, till the 9th of February. During this time I made some examinations between Moke Creek and the north shore of the middle part of Lake Wakatipu.

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* *See* Report on Motunau District, p. 108.

Leaving Kinloch on the 11th of February, I went to the Upper Route Burn, and remained there till the 16th, making journeys in several directions.

I next moved to the west side of the range, and pitched the camp at the edge of the bush on the Lake Harris Range, whence the Route Burn track leads down to the Hollyford Valley. Leaving the tent at this place, I took a trip to the northward, along the higher parts of the Lake Harris Range. This trip in some respects proved a most unfortunate one, as the weather—which up till the 18th of February had, with the exception of two days, been fine—now broke, and it rained almost continuously for fourteen days. Besides the hardship which it entailed, this continuance of bad weather ruined in a great measure the expected results of this trip, as the small stock of provisions remaining would not warrant me in carrying out the plan I had intended to follow.

After remaining for a week under such shelter as could be found at this place, the hopeless condition of the weather and failing provisions compelled a return to the camp at Lake Harris. This proved no easy task, as the ground which had to be passed over is exceptionally rough, even for this district, and dense fogs prevented choice in the matter of selecting the best road.

Arrived at Lake Harris, the weather did not in any respect improve, and the first opportunity of returning to the east side of the range had to be taken advantage of. It was not before the 6th of March that this opportunity arrived, on which day I returned to the hut in the upper part of the Route Burn Valley.

On the 7th the camp was pitched at the first crossing of the Route Burn, and a supply of provisions obtained from the neighbouring station in the Dart Valley. At this place I remained till the 10th of March, examining the rocks in the vicinity; but, bad weather still continuing, I returned on that date to Kinloch, and to Queenstown on the 12th of March.

On the 14th of March I again left Queenstown for the west side of Lake Wakatipu, landing at the mouth of the Von River, west of which I intended crossing the Livingstone Mountains to the upper part of the Eglinton River. When just starting for this part of the district I was recalled to Queenstown, to which place I returned on the 17th of March.

On the 19th of March I again went to the head of Lake Wakatipu, and examined the valley of the Rees River, and the range between the upper arm of Lake Wakatipu and the Shotover River, returning to Queenstown on the 26th.

From the 27th of March to the 6th of April I was engaged along the east side of the range between the upper arm of Lake Wakatipu and the Shotover River, examining the rocks at Bob's Cove—the Twelve-Mile—on the north shore of the lake; in Moke Creek, Dead-Horse Creek, and as far along this side of the range as Mount Gilbert, on the north side of the Moonlight Gorge.

DESCRIPTION OF THE DISTRICT.

The district requiring description for the purpose of making clear references to natural features or localities which will have to be mentioned in that part of this report which deals with the geology of the district is bounded on the east by the south bend of Lake Wakatipu, and a line north of the Shotover Valley.

The northern boundary may be taken from Centaur Peak across the Forbes Mountains to Cosmos Peak, and thence in a north-west line to Red Mountain, at the back of Big Bay.

From Red Mountain the western boundary follows south along the valley between Skipper's Range and the Bryneira Mountains to the junction of Pyke's Creek with the Hollyford River. Crossing the Hollyford Valley at this point, the eastern slopes of the Darran chain of mountains are taken as the further boundary to the southward as far as the saddle leading from Gunn Lake into the upper part of the Eglinton River. Thence a south-east line may be taken to the junction of the north and south branches of the Von River, and thence east to Half-way Bay, on the west side of the south bend of Lake Wakatipu. The altitudes of the mountains and other particulars of the physical geography of the central range and eastern watershed of this district were first described* by Mr. James McKerrow, F.R.G.S. (now Surveyor-General), and those of the western watershed by Dr. Hector.†

The tract of country included within these boundaries is of an excessively mountainous description, and lies partly on the western and partly on the south-east side of the main watershed of this part of the South Island. The principal mountain chains are the Forbes Mountains, in the north-east corner of the district, the northern prolongation of which forms part of the watershed between the East and West Coasts.

The Richardson Mountains trend north from the middle part of Lake Wakatipu along the eastern side of the northern part of the district. West of the Forbes Mountains the main watershed is continued to the south-west as a high mountain range, of which Cosmos Peak is the highest point of elevation.

South-west and west of Cosmos Peak are the Lake Harris Range and the Bryneira Mountains, the latter stretching north to Red Mountain, on the boundary of the district. West of the Bryneira Mountains, between these and the coast-line, is the Skipper's Range. East of Lake Harris Range, and north of the Greenstone River, the Humboldt Mountains overlook the northern bend of Lake Wakatipu, and trend in a north-and-south direction. The Eyre Mountains are situate in the south-east part of the district, south of the middle part and west of the south bend of Lake Wakatipu. The Thomson and Ailsa Mountains are a continuation

* Otago *Gazette*, 1863, p. 381.
† *Ib.*, p. 435. *See also* Jour. Roy. Geog. Soc., 1864.

to the south of the Lake Harris Range. West of the Hollyford Valley the rugged chain of the Darran Mountains lies between that valley and Milford Sound.

Along the northern boundary the principal mountains are all above 8,000 feet in height where these lie within the east and south watershed. West of the main watershed, along the same line, the mountains do not attain a height of more than 6,500 feet. Along the western boundary, the Darran Mountains rise in a series of rugged peaks, several of which are over 8,000 feet. In the Forbes Mountains, the highest peak is Mount Earnslaw, 9,169 feet, situate near the southern termination of the chain, and not in that part of the same range which forms the main watershed, that part of the range not being so high by more than 1,000 feet. The Cosmos Peak, standing on the main watershed west of Mount Earnslaw, is over 8,000 feet in height, and is surrounded by high and excessively rugged mountains. The highest part of the Bryneira Mountains, though carrying permanent snow-fields of considerable extent, is not much more than 7,000 feet in height.

In the Darran Chain, lying west of the Hollyford Valley, the higher peaks, Mount Christina and Tutuko Peak, are both between 8,000 and 9,000 feet, the latter appearing to be the higher mountain of the two. The whole of this range is a succession of peaks, in height not far short of the above-named mountains.

In the Humboldt Mountains, the central highest peak, Mount Bonpland, rises to a height of 8,102 feet, while in the same range Bald Peak and Upper Peak are both nearly 7,000 feet. Further to the west and north-west, in the Lake Harris Range, the mountains are nearly all over 7,000 feet. To the south of the Lake Harris Chain, David Peaks (at the northern end of the Livingstone Mountains), Moffat Peak (in the same range), Mount Mavora (south-east of Moffat Peak), and Mount Turnbull (east of the middle part of the Thomson Mountains), are all between 6,500 feet and 7,000 feet in height.

Further to the east, the more important peaks of the northern part of the Eyre Mountains are Cecil Peak and Walter Peak, respectively 6,487 feet and 5,956 feet. In the same neighbourhood, *i.e.*, on the south side of the middle bend of Lake Wakatipu, Afton Peak and Mount Nicholas are about 5,000 feet in height.

The highest point of the Richardson Mountains is Mount Larkin, 7,432 feet, standing nearly opposite the upper end of Lake Wakatipu, near which, to the south-west, is Stone Peak, nearly as high.

Towards the northern end of the range the mountains are less in height than Mount Larkins, Temple Peak being 6,731 feet, while Stair Peak, yet further north, is 6,644 feet. Mount Aurum, terminating in a spur range, which from Temple Peak runs east towards the upper part of Shotover River, rises to a height of fully 7,000 feet. At the southern end of the range, Mount Crichton overlooks the middle and upper bend of Lake Wakatipu, rising to a height of 6,185 feet; while Ben Lomond, north-west of Queenstown, is 5,747 feet.

Except the Shotover River, which bounds the northern part of the district on the east side, and the Hollyford River, which with its tributaries forms Lake McKerrow, and thence has its outlet to the sea at Martin's Bay on the West Coast, all the other streams of the district fall into Lake Wakatipu. The tributaries of the Shotover draining the east slopes of the Richardson Mountains are Moke and Moonlight Creeks, Stony Creek and Skipper's Creek further to the north. On the west side of the range, and falling into the upper part of Lake Wakatipu, are Simpson's Creek, or the Twenty-five-Mile, Stony Burn, and the Buckler Burn, the first and last cutting deeply into the range. Further to the north, draining the same side of this range, but falling into the Rees River, the more important creeks are Precipice Creek, the Twelve-Mile or Temple Burn, and, above the point where the Rees River emerges from the narrow valley, several unnamed creeks, all of which cut deep rocky gorges through the lower slopes of the range before joining the main river.

Lake Wakatipu, varying from two to four miles in width, from Kingston at the southern end of the lake trends north to Queenstown, a distance of twenty miles. Between Queenstown and the north-east spurs of Cecil Peak it turns to the west, trending in this direction a distance of twelve miles to near the mouth of the Von River, where, turning again to the north, the upper bend from the mouth of the Von River to Kinloch at the head of the lake is seventeen miles. The Von River and the Greenstone are the only considerable streams falling into the lake on the west side, the Von River at the point already indicated and the Greenstone six miles from the head of the lake. The first of these drains the eastern slopes of the Thomson Mountains, and its southern branch part of the Eyre Mountains to the south-east.

The Greenstone drains the western slopes of the Humboldt Mountains, the Ailsa, and the northern end of the Livingstone Mountains, its principal tributary being the Capels branch, making junction with the main stream three miles from its mouth and coming from the north. Of the two rivers falling into the upper part of Lake Wakatipu, by far the larger is the Dart River, which drains the main range from the north end of the Humboldt Mountains to the point where the Forbes Mountains in their north-eastern extension become part of the principal watershed of the country. The actual position of its main sources has not yet been determined. Numerous large streams coming from the glaciers and snow-fields of the Cosmos Peak, Mount Earnslaw, and the high ranges, the continuation of these appears to form a large river without any one source-branch being greatly larger than another. The first part of its course is through a deep narrow valley, of which little is known, the direction of which is south-west to the junction of Beans Burn. This stream drains the southern slopes of Cosmos Peak, and flows south-south-east to its junction with the Dart, twenty miles above Lake Wakatipu. On the same side the Dart receives the Rock Burn and the Route Burn. Below the junction of the last-named stream the Dart flows along a wide shingle-bed, breaking into (in the lower part of its course) a perfect network of streams, which with the shingle-banks between covers a breadth of nearly two miles, and falls into Lake Wakatipu on the west side of the upper end of the lake. The area of country drained by this river is so comparatively small that, looking at the great body of water which forms it, a knowledge that its sources spring from numerous large glaciers seems scarcely sufficient to account for its great volume.

The Rees River, draining the eastern slopes of Mount Earnslaw and the same side of the southern part of the Forbes Mountains, and the western slopes of the northern part of the Richardson Mountains, is a river greatly less in volume than the Dart. Before it receives the outlet of Diamond Lake the stream is not larger than the Shotover in the lower part of its course. Above the termination of the eastern spur of Mount Earnslaw, the Rees flows south in a narrow valley between high mountains, the peak of Mount Earnslaw towering above its valley nearly 8,000 feet. In the lower part of its course the Rees, like the Dart River, expands, covering a wide shingle-bed bordered by swampy land, backed by terraces along the lower slopes of the Richardson Mountains.

Earnslaw Burn is a stream of considerable size. It rises from a large glacier on the southern face of Mount Earnslaw, and flows into Diamond Lake, which is close under the north-eastern slopes of Mount Alfred. The outlet of this lake gives to the Rees River a volume of water equal to that which it joins. At times when the rivers are flooded the Dart and the Rees partly unite, but at ordinary times the Rees falls into the lake at the eastern corner of its upper end.

On the western side of the main watershed the Hollyford River carries to the sea all the waters of this district. Taking its rise from Gunn Lake, west of the upper part of the Greenstone Valley, the Hollyford River has a north-north-east course along a narrow valley to the junction of Pyke's Creek, a large stream coming directly from the north. From the Darran Chain to the west, the Hollyford receives numerous large creeks feeding from the glaciers and snow-fields which throughout the year clothe these mountains. On the east side, coming from the Lake Harris Range, numerous streams of lesser volume are supplied. Hidden Falls Creek is the largest stream joining the Hollyford from the north-east before reaching Pyke's Creek. This stream, passing between them through a deep gorge, breaks the continuity of Lake Harris

Range and the Bryneira Mountains, which lower part of its course is in a nearly east-and-west direction. Above the gorge this creek has a course nearly north and south along a deep narrow valley between the Bryneira Mountains to the west, and the main watershed between it and the Dart Valley to the east. After a course of five or six miles in this direction, Hidden Falls Creek takes its rise from a small lake on a marshy saddle dividing the northern end of the Bryneira Mountains from a spur range springing from the block of mountains on the main watershed between the Bean Burn and Rock Burn Saddles. On the same saddle from which Hidden Falls Creek flows south and then west to the Hollyford River, the Whitburn Creek flows to the north in a continuation of the same valley. Passing the northern end of the Bryneira Mountains the Whitburn Creek makes junction with a large stream which, taking its rise from the western slopes of Cosmos Peak, flows north-west and then west to the junction of Whitburn Creek, where the united creek turns south and falls into Lake Alabaster, lying between Skipper's Range and the western slopes of the Bryneira Mountains.

Pyke's Creek, forming the outlet of Lake Alabaster, flows south to the Hollyford River, and is a large stream which more appropriately should have been spoken of as a river.

The level lands of the district are confined to the valleys of the larger rivers, and, in their extent, are unimportant, save as being the only lands available for settlement.

Lake Wakatipu having at one time stood at a much higher level than it does at present, a fringe of terraces surround it, which vary from a breadth of a few yards to a mile according as the mountains are abrupt or have a more moderate slope towards the lake.

The Dart and Rees Rivers have also succeeded in reclaiming from the upper part of the lake a tract of land six or eight miles in length, having a breadth of three to four miles, and in the valleys of these rivers there is, in places, some small extent of flat land beyond, high enough to be beyond the destructive influence of the rivers. Near the head of Lake Wakatipu a good deal of the low lands is liable to be swamped when the rivers are flooded. Along the middle part of the Greenstone Valley there are some flat lands, but these are neither extensive nor at the present time of much value.

The last twenty miles of the Hollyford Valley, before the river enters Lake McKerrow, have a width of level land, which, on the average, is not more than two miles. Elsewhere small patches of level land may be found which have been omitted in this enumeration; but these are wholly unimportant.

Passes.

Only a few of the more important passes need be mentioned. Hector's Pass, which by way of the Upper Greenstone leads into the Hollyford Valley, deserves to be placed foremost on the list, as it is the only route at all times available whereby the West Coast can be reached from Lake Wakatipu. The saddle on this route lies at about 1,800 feet above sea-level. The approach from the eastward is gradual, Lake Wakatipu, distant twenty miles (by the track), being 1,069 feet above the sea. The saddle forms a depression between the south end of the Lake Harris Range and the northern prolongation of the Livingstone Mountains. To the north-west the descent into the Hollyford Valley is more abrupt than the approach to the saddle from the eastward, but the Hollyford Valley can be reached without any serious difficulty.

A low saddle lies at the source of the main stream falling into Gunn Lake, which, judging from the line limiting the upper boundary of the bush, cannot be more than 2,500 feet above the sea. This leads into the Eglinton River, which falls into Lake Te Anau, and can be reached only by long and difficult approaches, so that at present it is of little importance.

Eight or ten miles north of the Greenstone Pass the Lake Harris Range is crossed by the Route Burn Saddle at a height of 4,100 feet. The approach to this leading from the Dart Valley up the Route Burn is much more difficult than from the mouth of the Greenstone River to the Greenstone Pass. The height of the saddle at Lake Harris is also a fatal objection to this being used as a means of reaching the Hollyford Valley and the West Coast, as during many months it is deeply covered with snow. In sheltered places snow lies on the Lake Harris Range throughout the year at elevations under 5,000 feet.

The descent to the west from the Route Burn Saddle at Lake Harris is very abrupt. At the source of the north branch of the Route Burn a high saddle (5,200 feet) leads past the north end of the Lake Harris Range. This should lead down to the middle part of Hidden Falls Creek, but the range on the north-west side is so rugged and abrupt that no means of descent has yet been found, and Hidden Falls Creek can only be reached by again crossing to the east side of the watershed, some distance to the north-east, thereby reaching the upper part of the Rock Burn, whence the range can at times be followed to a saddle at the source of that creek, which, though high, is practicable, and leads into the upper part of Hidden Falls Creek.

Snow continually lies 800 feet from the summit of the north Route Burn saddle, filling the southern slope to a great depth, but the actual saddle and the northern slopes are from mid-summer to April generally free from snow. The Rock Burn Saddle has been passed several times, and sheep have also been driven over it, there being grass lands in the upper part of Hidden Falls Creek, which an attempt was made to utilize.

Yet another pass crosses the main watershed at the source of Beans Burn, six or seven miles to the north-east of the Rock Burn Saddle. This Beans Burn Saddle is very difficult to reach from the Dart Valley, but is low enough to be clear of snow by midsummer. This saddle crosses the main watershed just under the slopes of Cosmos Peak, and leads into the upper valley of the large creek which, with Whitburn Creek, forms the main feeder of Lake Alabaster.

The Darran Mountains, from opposite the upper end of Lake McKerrow to Mount Christina, appear to be a range of mountains everywhere impassable. A large creek comes from this range south-east of Mount Christina, which may possibly lead up to a pass in the range, but such has not been found as yet. At no other point does it seem possible to cross this range as it is followed to the north till reaching a point on the range opposite the junction of the Greenstone and Lake Harris tracks, in the Hollyford Valley, where a large creek, which a little further down the valley joins the Hollyford from the west, looks from the opposite mountains as if it led to a saddle by which the Darran Mountains might perhaps be crossed so as to reach the Cleddau River, which, followed down, falls into the upper part of Milford Sound.

From the higher parts of the north end of the Lake Harris Range, this saddle and the whole of the approach thereto from the Hollyford Valley was distinctly seen. The creek by which the approach to this pass will have to be made, on leaving the lower grounds along the Hollyford River, is confined in its course (though not strictly passing through a gorge), and has, for the first mile, a rapid fall. It is here that the only difficulty on the east side of the range may be looked for. Higher up the creek the valley widens and slopes gently, having patches of open grass land along its banks, surrounded by bush. Along this part of its course the bed of the stream is from 1,800 to 2,000 feet above the sea. Beyond this an abrupt rocky barrier stretches nearly across the valley, which here is somewhat more than half a mile wide. This parapet of rocks may be passed on the north side of the valley. Hitherto the creek has had a westerly course: now it turns to the south-west, and passes partly on the south side of its lower part. The rocky barrier already mentioned marks the 3,500-feet line, and the upward limit of forest growth.

Having gained or passed beyond the rocky barrier at the height above mentioned, the ground to be passed over is again comparatively level, forming a sort of basin between the surrounding mountains. From the upper edge of this, if looking south-west, the pass lies on the left hand, or directly behind the mountain standing south of the lower part of the creek, and already mentioned. The pass is a shingle saddle, apparently easy to be gained from the basin below, and cannot be more than 800 to 1,200 feet higher than the bush-line, which on the Lake Harris Range is limited to 3,300 feet. When seen from Lake Harris, about the end of March, no snow was to be seen on the saddle nor on the adjoining range for another 800 to 1,000 feet of elevation, which leads me to believe that I have not under-estimated the height of the saddle itself.

What is the nature of the descent to the westward could not be seen from the point of view on the Harris Range, but as placed upon the map the distance to the Cleddau River is as far as from the saddle to the Hollyford River. The first part is evidently along the bottom of a deep gorge, to reach which from the saddle may be a very abrupt descent, although this may prove easier than it appears to be. If the west side is not greatly more difficult than the approach to the saddle from the east, there is no doubt that this pass can be used during the summer months as a short route—and, as it seems, the only possible one by land—from the Lake District to Milford Sound. While in this district, had the weather been less stormy than it was, or the Hollyford River crossable, the nature of the western approach to this saddle had been ascertained.

Taking a comprehensive view of the district, and extending this so as to include portions of the provincial district both to the north-east and the south-west, it will be prominently apparent that the great feature of the whole is the massive mountain ranges grouped along the north and western parts of the district. The district elsewhere may be said to be mountainous throughout, but attention is naturally directed to the snow-clad giants which dwarf by comparison the otherwise more than respectable ranges of the south and east.

To the north and west every here and there a stupendous peak rises above the general elevation of the particular range to which it may belong. These however do not arrange themselves in a direct line corresponding to the general or approximate water-shed. On the contrary, they are scattered, as at first sight it seems promiscuously, over a belt of country more than twenty miles in width, which extends in a north-east and south-west direction, or nearly parallel to the west coast of the Island. This, however, is not the direction of the ranges generally, if taken singly and in detail. As has already been pointed out, these, with some few exceptions, trend in a north-and-south direction; and, whether ruled by the mountains as lines of elevation, or themselves determining the direction of the ranges, the valleys of the larger rivers have also a north and south direction.

From a standpoint which may be taken, say, from the top of Ben Lomond, immediately north of the east-and-west bend of Lake

Wakatipu, if we look to the north and north-east there lies before us a country mountainous indeed and deeply cut into by its various streams, but still giving the impression of an elevated tract of country having a swelling rounded appearance, in which denudation has evidently as yet failed to produce the rugged and serried outlines of the mountains to the north-west and south.*

To the south and west it is evident that the rocks have yielded more readily to denuding agents, and not merely are the larger valleys deeper cut, but the smaller streams have cross-cut and hacked the once more continuous ranges till on the west side of the lower part of Lake Wakatipu the north part of the Eyre Mountains is little more than a sea of isolated peaks, connected only by the deep saddles which are everywhere to be found in this part of the district.

Further to the west, before reaching the crystalline rocks, the ranges are not so rugged, being formed of yielding strata which strew their slopes with great sloping fields of *débris*. From the same standpoint, Ben Lomond, if the valley systems of the district (as far as from this point they can be seen) be considered, it cannot but be observed that the valley of the Shotover River lies on the same line and is indeed continuous with the lower bend of Lake Wakatipu. This river at one time entered Lake Wakatipu—when it stood at a higher level—at Arthur's Point, three miles from Queenstown. The east-and-west bend of Lake Wakatipu is the direct continuation of the Kawarau Valley from the Arrow junction, and thus we have two valleys, the one crossing the other nearly at right angles.

The north bend of Lake Wakatipu, and its continuation north as the Dart Valley, run north and south, parallel to the south bend and Shotover Valley. Strangely enough, the Dart Valley and the upper bend of Lake Wakatipu have a southern continuation in the valley of the Von River, which corresponds to the northern continuation of the south bend along the valley of the Shotover.

On the west side of the main watershed the Hollyford Valley runs nearly parallel to that of the Dart River on the east side, the sources of the two rivers overlapping each other to a very considerable extent.

GENERAL GEOLOGICAL STRUCTURE OF THE DISTRICT.

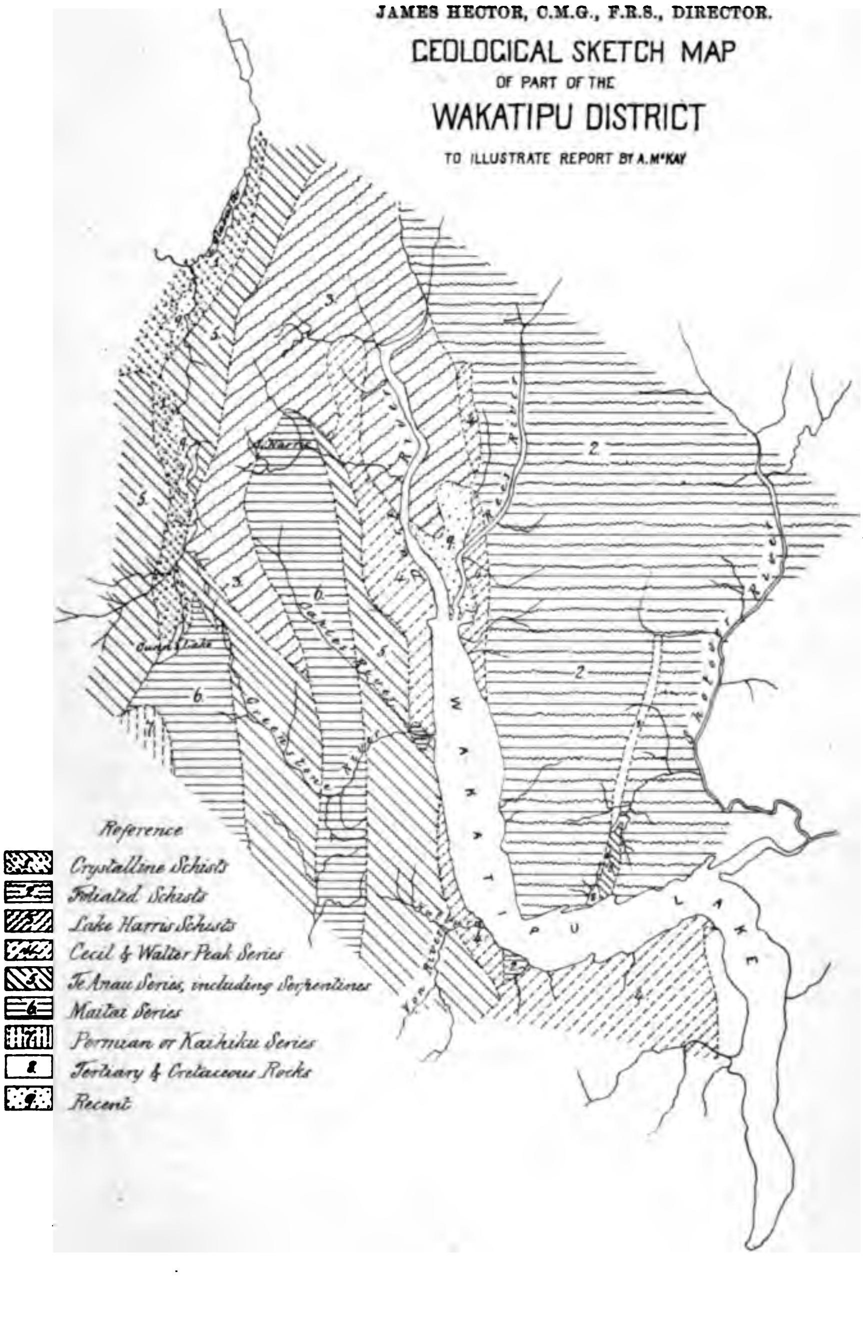
East of Lake Wakatipu and the Rees River, with small exceptions all the rocks are metamorphic schists, of which everywhere the dip is west or south-west. West of the south bend of the lake a series of less altered rocks (phyllites) form the northern part of the Eyre Mountains. The same rock, overlaid or in part replaced

* This is the impression conveyed, as seen from a distance—not the actual condition of the country, which is described by Dr. Hector as a "country extremely broken, the mountains rising to 7,000 feet above sea-level, intersected by valleys 3,000 to 4,000 feet in depth."—Geological Reports, 1878-79, p. 23.

Geological Survey of New Zealand.

JAMES HECTOR, C.M.G., F.R.S., DIRECTOR.

GEOLOGICAL SKETCH MAP
OF PART OF THE
WAKATIPU DISTRICT
TO ILLUSTRATE REPORT BY A. McKAY



by a flaggy dark-blue subschistose rock, fills the valley of the Dart in its lower part, and is present on the higher parts of the mountains as far north as the Beans Burn. This rock forms the base of the south end of the Humboldt Range, and in its central part the highest peak (Mount Bonpland). It rises to a great height on Mount Earnslaw, and is seen on the east side of the valley at the head of the lake. South of the mouth of the Greenstone River it is overlaid by younger rocks. The same rock forms the three islands in the upper reach of Lake Wakatipu. These rocks dip west or south with less regularity than the underlying crystalline series. In the upper part of the Dart Valley, and the northern part of the Eyre Mountains, they form synclines running in a north-and-south direction.

Spreading over the whole breadth of the southern part of the district, from the Von River westward, are unaltered Palæozoic rocks, forming the Thomson and Livingstone Mountains, and part of the eastern slopes of the Darran Chain. These extend north, split into two lines of exposure by the Lake Harris Range, which is mainly composed of schistose rocks. The eastern line terminates between the Rock Burn and the Route Burn, and lies wholly to the east of the main watershed. The western line of extension of these rocks is narrowed, and almost confined to the eastern slopes of the Darran Mountains from the foot of the Greenstone Pass, in the Upper Hollyford, to nearly abreast of Lake Harris. North of this place they form not only the higher part of the Darran Mountains as far as Tutako Peak, but also the western slopes of the north part of Lake Harris Range, and the whole of the Bryneira Mountains, widening out and spreading over a breadth of country on the northern boundary of the district.

The schistose rocks forming the mountains along the main watershed at the western sources of the Dart River are continued south along the Lake Harris Range, separating the two lines of younger unaltered rocks. The junction between the schists and these younger rocks is usually marked by serpentines and other magnesian rocks, accompanied by syenites and other crystalline rocks.

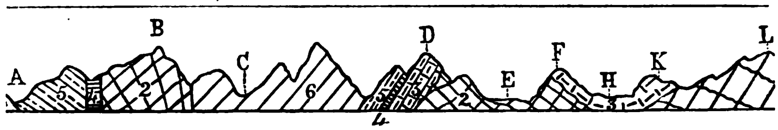
The gneiss-granite formation of the south-west coast of Otago is only seen as a narrow belt along the west side of the Hollyford Valley, and, but for the extreme depth to which this valley has been eroded, would not have been anywhere present in this district. Both Tertiary and Cretaceo-Tertiary rocks are developed on the north side of the middle part of Lake Wakatipu, and thence extend as a narrow strip, included as by a fault between the older rock along the eastern slopes of the Richardson Mountains, to Stony Creek, north of Mount Gilbert. With these Cretaceo-Tertiary rocks aphanite breccias belonging to the unaltered Palæozoic series are included along the same line, but have not been traced north of Butcher's Gully, on the south side of Moonlight Gorge.

There is a marked unconformity between the crystalline schists and the less altered rocks of the eastern part of the district. Between the latter and the overlying Palæozoic rocks unconformity is not so apparent, but the presence of the serpentine belt often renders obscure the relations of the two formations.

The following is a table of the different formations which occur in the district, the ages assigned to these being according to the latest Geological Survey classification :—*

Table of Formations.

Age.	Formation.	Principal Area of Development.
I., II. Recent to Pliocene	Alluvium & glacier deposits	In favourable situations everywhere.
IV. Lower Miocene	Pareora Formation	On the north shore of Lake Wakatipu.
VI. Lower Eocene to Lower Greensand	Cretaceo - Tertiary Series	Chiefly on the north side of Lake Wakatipu.
XI. Permian ...	Kaihiku Series ...	South-west corner of the district.
XIIA. Carboniferous	Maitai Series ...	Between Humboldt and Lake Harris Range.
XIIB. Upper Devonian	Te Anau Series ...	Largely covering the south and west parts of the district.
XIII. Lower Devonian (?)	Phyllites and blue slate	Eyre Mountains, valley of the Dart River, &c.
XVI.	Foliated schists—Upper Middle Lower	North-east part of the district—the Forbes Mountains, and main watershed to south-west of Lake Harris Range.
XVII.	Crystalline schists	Flanks of Darran Mountains, on the west side of the Hollyford Valley.



Section (1)—From Hollyford Valley, across Lake Harris Range and Humboldt Mountains, to Richardson Mountains. 1. Crystalline schists. 2. Foliated schists. 3. Lake Harris schists. 4. Cecil and Walter Peak series. 5. Serpentines. 6. Te Anau series. A. Hollyford Valley. B. Lake Harris Range. C. Upper Route Burn. D. Upper Peak. E. Dart River. F. Mount Alfred. H. Rees River. K. Precipice Hill. L. Richardson Mountains.

FORMATION XVII.—CRYSTALLINE SCHISTS.

These rocks have within this district a very limited exposure, as shown in Section (1). They are seen only along the west side of the Hollyford Valley, and some distance back towards the higher parts of the Darran Mountains, where the larger creeks

* Hector, Geological Reports, 1878–79, p. 2, *et seq.*

have cut deeply into the range. They form, without doubt, the great bulk of the range, the younger overlying rocks which hide them forming the higher parts only. No opportunity offered by which these rocks could be examined closely and specimens obtained which would show their character, but there can be no doubt that they are correctly classified as belonging to the crystalline schists of the Sounds and south-west of Otago. Their outcrop in the Hollyford Valley is confined to levels below the bush-line, except in the sides of the deeper-cut transverse valleys. From the high levels of the opposite side of the valley they can be traced as a light-grey rock as far south as immediately north of Gunn Lake. Beyond this in the same line the country is not sufficiently cut into to expose them, and they still are overlaid by a younger formation on the higher part of the ranges, apparently as far as the head of Te Anau Lake.

In his report on the Te Anau District Mr. Cox describes the rocks of this formation as dipping east-north-east at high angles, and shows on the map accompanying that report the junction between this and the directly overlying series as taking place at the head of the Lake. This, as the point of its disappearance to the east with the strike of the rocks as given, agrees with what is seen in the Hollyford Valley, and shows that, were a deep valley excavated along the flanks of the range from here to the head of Te Anau Lake, exactly the same section would be laid bare. The crystalline schists would appear as a narrow belt along the west side of such valley, while the east slopes of the mountains to the west would yet be composed of younger rocks, which would also form the east side of such a valley, these being the exact conditions of the upper part of the Hollyford Valley.

FORMATION XVI.—FOLIATED SCHISTS.

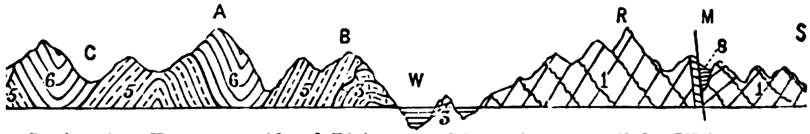
These rocks have been grouped by Dr. Hector under three divisions, Upper, Middle, and Lower (Geological Reports, 1878–79, p. 14), each distinguished by a different lithological character. The Upper Division, as given in the above report, may possibly be the series next to be considered, which cannot be described under the present heading, both on account of a mineral difference and also a high unconformity.

The foliated schists may still be divided into three groups mineralogically, but it is questionable if these be stratigraphically distinct. They cannot in section be shown to be so without calling to aid an enormous degree of faulting along certain lines, which requires to be again and again repeated, and which, although true in one particular instance, cannot be said to be proved in the other cases. On the whole, the mineral distinctions appear to alternate several times with each other. Facts, however, lead so as to favour the opinion that the soft blue micaceous slates of the Middle Division have yielded the most of the gold found in the

Western or Lake District,* as wherever any important find has been made this rock is sure to be present, and many promising creeks which do not show this rock have not yielded gold to the extent which might have been expected. Even in particular creeks, such as the Buckler Burn and Moke Creek, on passing these rocks the gold has suddenly become too poor in the wash to pay for working. This has generally by diggers been attributed to the harder bottom formed by the other rocks, which are thus not able to retain the gold; but such may not be the only reason. These rocks form the whole of the country east of Lake Wakatipu with exceptions already pointed out.

A few miles below the head of the lake on the east side, these rocks pass under a newer series, and the western boundary of the foliated schists is here and for some distance to the north obscured by terrace, alluvial, and glacier deposits. In these lower grounds where rocks are seen they belong to the younger beds; and Precipice Hill, east of the Rees River and four miles north of the lake, belongs to the younger series. The boundary thence strikes to the mouth of the Twelve-Mile Creek, Temple Burn. An alluvial flat intervening, it is next seen in the south end and east side of the western spur of Mount Earnslaw, the rocks now under consideration forming the great mass of that mountain. From the western slopes of Earnslaw the boundary strikes north-west across the Dart Valley to the rugged block of mountains north-east of the Rock Burn. From this point it turns to the south-west and south, a narrow strip between younger rocks striking south-south-east to the north spur of Upper Peak, and apparently across the Dart River to the north end and west side of Mount Alfred.

From the middle or upper part of the Route Burn the boundary strikes west across the high mountains between there and the upper part of the north branch of the Route Burn to the north end of the Lake Harris Range. Thence it turns south along the higher eastern slopes of the range, crossing the upper part of the Capels Branch of the Greenstone River. The formation appears to terminate with the Ailsa Mountains: at least there is no evidence showing its presence south of the Greenstone Valley. For the general relations of this, see Section (2).



Section (2)—From west side of Livingstone Mountains across Lake Wakatipu to Shotover River. 1. Foliated schists. 3. Lake Harris schists. 5. Serpentines. 6. Te Anau series. 7. Maitai series. 8. Tertiary and Cretaceous rocks. A. Ailsa Mountains. B. Greenstone Spur. C. Greenstone Valley. M. Moonlight Gorge. R. Richardson Mountains. S. Shotover River. W. Lake Wakatipu.

* Hector, *loc. cit.*, p. 14. *Also* Report on Otago Gold Fields, Otago *Gazette*, 27th August, 1862.

In the southern end of the Lake Harris Range the foliated schists have no great breadth of exposure, but reach down to the Hollyford Valley, on the west side of the range between Stony Creek and High Falls Creek. From this point younger rocks form the western slopes of the range as it is followed to the north. The western boundary of the schists gradually rises higher and encroaches on the central part of the range, till at the northern end of the range the boundary is in a line with the upper part of Hidden Falls Creek. This it follows for some distance, till opposite the Rock Burn Saddle it leaves the valley of Hidden Falls Creek and strikes across the intervening range, bounding on the east the upper part of that valley, and thence strikes along the western side of the main watershed to the northern boundary of the district.

On the Lake Harris Range, the rocks of this series dip at high angles to the east, especially along the eastern boundary. At Lake Harris the strata are nearly vertical. On the west side of the range the rocks, though underlying, dip at lower angles. At the north end of the range, and on the main watershed between the Snow Saddle at the source of the north branch of the Route Burn and the Rock Burn Saddle, the rocks are vertical or dip east at high angles. The rocks themselves are a massive green schistose rock, with veins and crystals of specular iron freely scattered throughout. This, although the most prominent, is perhaps not the most abundant rock. A grey pyritous quartzite or quartz schist in thick and ever-recurring bands forms a prominent feature of the Lake Harris Range, and is particularly strongly developed on the west side of the main watershed, north-east of the Lake Harris Range.

Soft blue mica-schists occur interbedded with both the quartzite and green rocks, but have not the prominence of these latter. A red schistose slate, and in places a dark fibrous slate (carbon-slate of Mount Arthur and the Baton River, Nelson), are found at Lake Harris and along the eastern boundary in the north branch of the Route Burn. In many places there are grey or reddish schists with laminæ of hæmatite iron as thin irregular streaks between the slate.

Near the eastern border, and therefore, according to the dip, in the higher rocks, some of the rocks become granular in structure, approaching the character of gneiss or syenite, of which a band running north and south crosses and appears on both sides of Lake Harris. Close to this band there are rapid changes in the character of the rocks, green, red, black, and blue schist lying to the east, while to the west the actual watershed immediately west of Lake Harris is green rock of varying hue, which shows this rock to be gnarled either structurally or by pressure to an extraordinary degree. I noticed many great blocks of this rock on the saddle leading from the North Route Burn into the watershed of Hidden

Falls Creek, the faces of which, where these had parted along a joint, showed like a gigantic slab of walnut-wood, the centre knots of darker green, almond-shaped, being 12 to 15 inches in diameter. Some of these blocks were 30 to 40 feet in length and 15 to 20 feet in height. On the west side of this saddle and some distance to the north, crystalline rocks, as syenitic or porphyritic rocks resembling those of the adjoining serpentine belt, appear in one or two places; but these are wholly unimportant as members of the series in which they occur, and may in reality not belong to it.

It has been said that this series has no great breadth of exposure in the north end of the Lake Harris Range. On passing along the range to the north-east, which terminates in an exceedingly abrupt ridge (which it is impossible to approach except by the further end), 6,500 feet in height, these rocks are seen from this to be developed some distance down the Rock Burn on its south-west side, while along the main divide north-east of the Rock Burn Saddle they form a high mountain, on the south-east face of which lies a very large snowfield.

On the south-east spurs of this mountain younger rocks make their appearance. The great depth of the Rock Burn Gorge exposes, lying beneath these younger rocks, those of the Lake Harris Range now treated of. These form the framework of the country, and are only obscured by the younger rocks. Their strike is still south, as in the Lake Harris Range, but the dip, though high, distinctly has changed to the west. Prolonging this line to the south the lower part of the Route Burn is reached, where again are exposed the gnarled and twisted green rocks of the Lake Harris Range, striking north and south, with a somewhat irregular dip, but which on the whole must be to the west.

These rocks crossing the lower Route Burn, and forming the northern spurs of Upper Peak, are identical in character with those of the same series described as occurring at Lake Harris. Possibly in the lower Route Burn these rocks form an anticline, but I am inclined to think that the evidences of this are nothing more than local disturbance due to the near presence of younger and intrusive rocks lying immediately to the westward.

A portion of Mount Alfred and the base of the western spur of Mount Earnslaw may be considered as belonging to these rocks as far as described, and which I take to represent the upper division of the foliated schists.

Beneath these, hard quartzose schists full of quartz laminæ with quartzite and beds of black mica form the east spur and higher part of Mount Earnslaw, and the Forbes Mountains west of all but the upper portion of the Rees River.

Further to the south these rocks strike more to the south-east along the western slopes of the Richardson Mountains to the shores of Lake Wakatipu. They are underlaid to the east by soft blue mica-slates, which, dipping west with an angle not greatly different from the slope of the range, give rise to such peculiarities as those of Mirror Peak, on which flat surfaces of considerable extent are exposed. These, looking towards the midday and afternoon sun, reflect its light with great brilliancy, and in clear weather as seen from the lake have a remarkable effect.

On the south end of the Richardson Mountains, unless shown to be otherwise by a careful observation of the strike, the softer mica-schists there appear to be the higher beds of this middle division of the series; and the same beds in the lower slopes of Mount Earnslaw should occupy the valley of Earnslaw Burn between the two bold southern spurs of that mountain.

The quartzose schists already mentioned as forming the east spur of Earnslaw are well shown in the Rees River bed two miles after passing the end of the spur following the river towards its source. On the western slopes of the opposite mountains a second belt of blue slate appears from beneath these rocks, dipping also at high angles to the west. This line of softer slate is bounded to the west by thicker-bedded green schists, the position of which is not in the Rees clearly seen on account of heavy slips covering the lower slopes of the range on the east side of the valley. The blue slates are however distinctly seen striking along the slopes of the range from the 2,500-foot to the 3,500-foot level, thence north, giving by their *débris* its characteristic name to Muddy Creek, and south across Temple Burn and the western middle slopes of the range to the gorge of the Buckler Burn. This line of softer slate is of some consequence, as it has evidently yielded a considerable amount of alluvial gold; and reefs—which are plentiful—are just beginning to be opened out in it. The "Invincible Reef," at present held by Davis and party in the Rees Valley north of Stair Peak, yields good prospects, and is of fair thickness—some three or four feet.

In the gorge of the Buckler Burn the blue slates are overlaid by a particularly heavy band of green rock, and themselves frequently alternate with harder rocks that break the mountain-sides into receding ledges where the creek does not exactly run at right angles across the strike. These harder ribs—generally formed of green hard schist or a brown quartzite—form frequent bars in the bed of the creek, on which rich finds have been obtained. From the middle part of the Buckler Burn, before breaking up into its source-branches, these rocks strike south-east across the eastern slopes of Mount Larkins to the neighbourhood of Lake Luna, situate between that mountain and Ben More, but do not appear to reach far enough to the east to form the rocks at the source of Moke Creek, or are otherwise interfered with in this direction.

Heavy bands of massive green rock lie to the eastward of this line of softer slate. Two principal bands of this rock are seen, with blue slate and quartzites between. These lie along the watershed of the range from Temple Peak south past the sources of the Buckler Burn, across Moonlight Creek, below Lake Luna, and above the gorge, taking in the higher part of Ben More, and terminating in the southern spurs of Ben More overlooking Moke Lake. These rocks are underlaid by slaty quartzites, weathering brown. These rocks are full of iron in various forms. Bisulphide of iron as large cubes of a deep-yellow colour, intimately associated with magnetite in octahedral crystals, occurs abundantly, traceable from the higher part of Ben More to the source of the left-hand branch of the Buckler Burn. "Black Maori," as specular iron or granular magnetite is locally termed by the diggers, is very abundant along this line.

A line of fault now interferes with the regularity of the sequence to the eastward. To the east of this fault it is probable that the whole of the rocks of the Richardson Mountains are repeated, but this involves faulting to such an extent as to appear almost incredible, were it not for the further evidence obtained on the south side of the east-and-west bend of Lake Wakatipu. On the north side of the lake this fault commences at Bob's Cove or the Twelve-Mile, and runs in the direction of the west side of Moke Lake. Marked along this line by the presence of younger rocks, the fault is by this means traceable further to the north. It crosses the south-east and east spurs of Ben More at about the 3,000-foot level. In this line it is continued across the various intervening gullies to the lower end of Moonlight Gorge. Further to the north it passes the eastern slopes of Mount Gilbert, crossing the upper part of Jones's Creek to Stony Creek, specimens of Tertiary or Cretaceo-Tertiary limestone being found as far north as Skipper's Creek.

Leaving for a time the consideration of the younger rocks, and commencing with the highest schistose rocks on the east side of the fault, these in Moke Creek are seen in the hills at the back of Skipper's and Gill's Terraces as soft blue mica-schist, dipping at high angles to the west. A band of harder chloritic schist is found at the point where the copper lode crosses Moke Creek; but under these to the east the soft blue mica-slates again appear, and continue to the junction of this with Moonlight Creek. These latter give place to granular chloritic schists with quartzites on the south side of the junction of Moke Creek with the Shotover, to the east of which soft blue schist again makes its appearance on the east bank of the Shotover.

The rocks associated with the Moke Creek copper lode strike south along the west side of McConachie's Creek, a small feeder of Moke Creek coming from the south, and, passing through the higher part of Ben Lomond, reach the north shore of Lake Wakatipu near the mouth of the Five-Mile Creek. To the north the same rocks strike across the hills to the lower end of the Moonlight Gorge, and are recognizable in this direction in the hills at the back of Gardiner and Lawton's home station, and in Dead-Horse Creek.

At the junctions of Butcher's, Dead-Horse, and Moke Creeks with Moonlight Creek, the blue slates are highly contorted, the contortions seen at the junction of Dead-Horse Creek being very remarkable. On the south bank of Moke Creek there are places where the strata, instead of being contorted in curved lines thrown back upon the original or principal dip of the rock, are crushed into sharp wavy lines at right angles to each other. The soft blue slates thus crushed and disturbed strike south across the Ben Lomond saddle to the shore of the lake, one mile from Queenstown, and are thus nearly in a line with the lower reach of Lake Wakatipu, from Queenstown to Kingston.

After passing the fault along the east slopes of the Richardson Mountains, the iron ores so abundant to the west appear absent from the rocks on the east side, but "black Maori" begins to show in the coarser schists along the west bank of the Shotover, below the junction of Moke Creek.

The total thickness of this series must be very great; but, in the view of its being faulted along different lines, no correct estimate can at present be given.

Dark-blue Slates of the Humboldt Range.

These rocks are present on the east side of the united and lower part of the Dart and Rees Valleys, showing as the rocks immediately overlying the foliated schists on the lower western slopes of the Richardson Mountains. In this locality they are clearly exposed, with a west and south-west dip, in Precipice Hill, passing by insensible gradations into a higher series marked by a distinctly different lithological character. On the west side of the upper part of Lake Wakatipu they were not examined further than while passing along the shore-line on board the steamer; but there is no reason to doubt their presence in the eastern base of the southern spur of the Humboldt Mountains for two or three miles below the head of the lake. Nearer the mouth of the Greenstone River they appear to be overlaid by the succeeding series above mentioned. As a dark-blue or black sub-schistose rock dipping east, and occasionally veined with leaders or small reefs of quartz, these rocks show on the shore-line north and south of McBride's saw-mill. Further north, along the west side of the Dart Valley, the lower slopes of the Humboldt Range being thickly buried in alluvium and covered with forest, these rocks cannot be observed at all points, but in various jutting rocks and in the beds of several of the creeks they are seen dipping south, south-west, and west, as they are followed to the north. In the southern end of this range they manifestly only form the lower eastern slopes, younger rock forming the upper part of Bald Peak, but, gradually rising higher as the range is followed north, in Mount Bonpland they reach the greatest elevation attained by this block of mountains. On the east and south-east slopes of Upper Peak they dip to the west, and pass behind the outer north-east spur of that mountain, which is formed of the Lake Harris schists already described.

In the lower part of the Route Burn the peculiar characteristics of this rock are not well developed, but sufficiently to show its presence. From the Route Burn, near the first crossing of that stream, the beds strike north, and form a saddle in the range dividing this stream from the next creek to the north—the Rock Burn. About the middle part of the Rock Burn these rocks cross to the block of mountains between that and the Beans Burn, and form the upper part of a high precipitous range, forming a spur from the main range to the west. At this latter point the rocks dip to the east at moderate angles, and are probably cut through by the deep gorge of the Rock Burn along the whole length of its course. Neither is it likely, for the same reason, were the alluvium removed, that these rocks would show in the Dart Valley. On the opposite western spur of Mount Earnslaw these rocks form the higher part of this ridge, with apparently a westerly dip, here cut off from connection with the other areas covered by this rock, but clearly indicating that, before the country was cut down by sub-aërial denudation to its present configuration, this was directly connected with an outlier of the same rock on the higher part of Mount Alfred, and at the same time with those forming part of Precipice Hill on the east side of the Rees River.

In Precipice Hill and on the west spur of Earnslaw the rocks dip westerly. On Mount Alfred the same rocks dip to the east. A syncline is thus formed, the axis of which is continued obliquely across the Dart, terminating between the Rock and Beans Burns, where the presence of these rocks has already been mentioned.

The east and north-east dip, noted as occurring on the west shore of Lake Wakatipu, would correspond to a south-south-east continuation of this line. But before reaching this point the rocks lose their high dip, and undulate rather than form sharp synclines and corresponding ridges; and there is, moreover, between the eastern base of Mount Bonpland and the Greenstone Spur a tendency to form a syncline in the opposite, or an east-and-west, direction.

There is some difficulty in determining to what series these rocks may belong, as, while they are unconformable to the Lake Harris schists resting equally upon these and the lower foliated schists, yet they and the next to be described underlie the Devonian and Carboniferous rocks of the Route Burn and Greenstone Rivers. Nor yet can they be safely identified with the Mount Stuart series, mentioned in last year's reports by Mr. Cox,* as he finds the

* Geological Reports, 1878-79, p. 42.

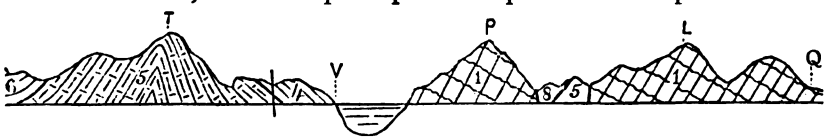
equivalents of these latter in the blue slates more immediately connected with the unaltered Te Anau and Maitai rocks.

The suggestion that these more altered rocks are after all only the equivalents of the younger unaltered Palæozoic rocks in the same district would indeed remove all difficulty respecting them; but, while admitting that they rise into these rocks apparently without a break, they yet underlie all the rocks that have hitherto been included with these.

Thus for the present I shall leave it an open question whether the blue slates here spoken of are the base of what may be taken as Middle Devonian rocks, or an entirely independent series, or even the equivalents of the Maitai series in a semi-metamorphic condition.

FORMATION XIII. (?).—LOWER DEVONIAN.
Cecil and Walter Peak Series.

These rocks, the position of which is shown in Section (3), as here indicated, have their principal development in that part of the



Section (3)—From Thomson Mountains, across Lake Wakatipu to Queenstown. 1. Foliated schists. 4. Cecil and Walter Peak series. 5. Serpentines. 6. Te Anau series. 8. Permian or Kaihiku series. T. Mount Turnbull. V. Mouth of Von River. P. Pickwick Hill. L. Spur of Ben Lomond. Q. Queenstown.

Eyre Mountains lying within the boundaries of the present district. On the south side of the east-and-west bend of Lake Wakatipu they form the greater part of Cecil Peak, and form Walter Peak and Afton Peak further to the west: indeed, with the exception of a narrow strip of foliated schists which stretches along the western shore of the south bend of Lake Wakatipu, the whole block of mountains east of the Von River, with the exception of Mount Nicholas, belongs to this series. In this part of the district these rocks form a syncline, which, to the eastward, rests upon foliated schists, presumably having the blue slates intervening between these and themselves. On the western side, between the mouth of Afton Burn and Mount Nicholas, they rest upon an older series, which appears to be the higher part of the foliated schists, curiously bounded on two sides by a double fault, and on the third side of the triangle by these rocks.

To the northward no rocks of this series are seen till reaching the islands in the upper reach of the lake, which are formed of these, as is the southern end of the spur of the Humboldt Range, which lies between the Capels branch of the Greenstone and Lake Wakatipu. On the east side of the lake the same beds begin abreast or a little north of the islands, and form a low ridge between the terraces and the higher range to the east, stretching north across the lower parts of Stony Burn and Buckler Burn. The same beds are well and characteristically exposed on the shores of the indentation of the lake now nearly enclosed by reclamation from the lake carried on by the Rees River. They extend yet north to the south end of Precipice Hill, where, as already stated, they are underlaid by the blue slates.

Where obscured by the alluvium of the Dart and Rees Rivers, unless wholly removed by the agencies which have given existence to the lake basin, these rocks, within this syncline, should extend a little further to the north, but, turning west and then south, should form the higher sequence of the rocks seen on the west shore of the lake, and, sweeping over the latter at the southern end of the Greenstone Spur, do strike north along the western slopes of that spur. In this manner they pass along the Humboldt Range, but in the higher and more rugged parts they have not been explored.

Three miles from the point where the Route Burn joins the Dart these rocks appear striking in a north-north-west direction, having a high dip to the westward. As here seen on the north face of Upper Peak they rest highly unconformably upon the Lake Harris schists, and are broken through by serpentines on their western border. As a granular rock that might often be mistaken for sandstone, there are with these frequent alternations of black fibrous rock (carbon-slate), which, as the beds are followed north across the Route Burn Valley, expand and show a decidedly more metamorphic condition than is the case of those beds in Upper Peak. In the deep, narrow gorge of the first creek joining the Route Burn from the north, after crossing the latter for the first time these rocks in character become almost identical with the Lower Silurian rocks of the Mount Arthur Range, in the north-west of Nelson. In places they are highly calcareous, and, close to their junction with the serpentines which separate these from the overlying aphanite breccias of the Te Anau series, beds of thin-bedded talcose slate alternate with the carbon-slates and a pale-green rock—aphanite.

FORMATION XIIB.—UPPER DEVONIAN.

Te Anau Series.

These rocks have a wide distribution over the south and western parts of the district. On the west side of the main range they stretch northward beyond the boundary of the district, and from the lower part of the Greenstone Valley extend along the higher western part of the Humboldt Range to the north side of the Route Burn Valley. An outlier of these rocks occurs on the north shore of the east-and-west reach of Lake Wakatipu, which is continued north-east past Moke Lake across the eastern spurs of Ben More, nearly into Dead-Horse Creek.

On the west side of the main range the Te Anau series is developed in the Bryneira Mountains as aphanite breccias, sandstones, and slates, striking north and south, and having a high but not excessive dip to the east. That part of the district was not examined, but they form the western slopes of the Lake Harris Range, their eastern boundary gradually striking lower and lower till south of Lake Harris it reaches the valley of the Hollyford River. Again it rises on the spur west of the Greenstone Pass.

South and west of this point these rocks rest on the crystalline schists, and, rising high in the eastern slopes of the ranges formed of these latter rocks, the aphanite breccias strike in the direction of the head of Te Anau Lake.

Serpentines and limestones, but with no apparent unconformity, mark the upper boundary of this series, and striking across the upper part of the Greenstone Valley they form first an anticline, and then to the eastward another syncline, the eastern side of which was examined and detailed last year by Mr. Cox.*

Further to the south, between the lower part of the Greenstone Valley and the mouth of the Von River, the eastern side of the last-mentioned syncline rolls over so as to form an anticline between the shore of Lake Wakatipu and a point eight or ten miles up the Greenstone Valley. The syncline, of which the western dip of this anticline forms one side, strikes north, forming the highly mountainous and excessively rugged country intervening between the Humboldt and Lake Harris Ranges.

The greater part of the rocks contained within this syncline belong to the overlying Maitai series, next to be described. In the section along the south bank of the Route Burn the definite arrangement of the strata as a syncline gives place to a general westerly dip, which is continued along the section till the higher beds abruptly terminate, these making contact with the schistose rocks of the Lake Harris Range between the second and last falls of the Route Burn. The character of this junction is that of nearly vertical strata on either hand. More to the north-east the beds along the junction-line dip to the south-east, but here the younger unaltered rocks terminate in a basin-shaped area, along the margins of which on the east, north, and west the dip is towards the central part. There is a close or almost continuous connection between the various areas in which these rocks are found, as hitherto described, but where found in the north shore of the east-and-west bend of Lake Wakatipu they are completely separated by a considerable distance from rocks of like character and the same age. In this latter locality their presence is due to the existence of a heavy fault, which not only involves these but much younger rocks also.

On the shores of the lake the exposure of the Te Anau series may be about a mile in breadth, but followed to the north beyond

* Geological Reports, 1878–79, p. 54.

Moke Creek this rapidly lessens, and the beds have not been recognized. The strata dip variously near Lake Wakatipu to the west, and north of Moke Creek, at very high angles. In the latter locality they clearly have the character of an aphanite breccia, which distinguishes some part of the series at all points where it is to any extent developed.

FORMATION XIIA.—CARBONIFEROUS.

Maitai Series.

These rocks are in many places not stratigraphically distinct from the Te Anau series. In the western part of the district they have their lower limit marked by the presence of heavy beds of grey subcrystalline limestone, which, on the western slopes of the Lake Harris Range, appear in connection with the breccias of the underlying series, and also close the same series further north in the Bryneira Mountains.

In the long spur terminating the Livingstone Mountains to the north these limestones form a syncline which, widening as it is followed to the south, develops between its sides a series of sandstones and slates, which must be regarded as belonging to the Maitai series. In the Route Burn from the first to the second falls the rocks, both from their position and character, must be considered as belonging to this series. The pale-green slates, with beds of fine-grained aphanite breccia, sandstones, and, higher in the section, blue slates, which form the rocks of this section, lie upon the coarser breccias and harder siliceous slates of the Te Anau series, forming the base of the section to the eastward. Already the fact has been mentioned that the western end of this section does not form with the east a syncline, and that it may have to be supposed that the Maitai rocks continue close up to the outcrop of the schistose rocks of the Lake Harris Range. At the present moment this is a matter of no importance, as it affects only the identity of the beds of a limited locality. It must, however, be supposed that the Maitai rocks are from the Route Burn Valley continued south across the Greenstone Valley, and across the pass leading from the latter into the upper part of the Mavora Valley, between the Thomson and Livingstone Mountains. The same beds of the Maitai series are developed to some extent along the west side of Lake Wakatipu, some distance north and south of the mouth of the Von River. In this part of the district the Maitai rocks are formed largely of grey fine-grained breccias, and the line of demarcation between them and the underlying Te Anau series is marked by talcose slate, passing in places into grey Maitai limestone. The beds are well exposed in the gorge of the Von River just before it enters the lake. The strike being south-west, the high dip of the beds is to the east. They are, however, abruptly terminated by a line of fault which, through Mount Nicholas, runs nearly north and south along the west side of the lake.

Serpentines, &c.

West of Lake Wakatipu, wherever Te Anau and Maitai rocks are developed, serpentines are sure to make their appearance along the boundary between these two formations, or between these and the older rocks with which they are in contact. From the northern boundary on the west side of the main range from Red Mountain serpentines are continuous along—first, the valley of Hidden Falls Creek to the point where this turns to the west to pass the north end of Lake Harris Range; thence along the west slopes of that range to the Hollyford Valley, at the western foot of the Greenstone Pass. This line of serpentinous rocks is generally less than a quarter of a mile wide, and often not more than three or four hundred feet. In breadth it appears to increase as it is followed north, and, as shown on the plan accompanying Mr. D. Macfarlane's report on the Jackson and Cascade Valleys, appears to extend in that direction to the near vicinity of Jackson's Bay.*

The principal rock is a dark-green, almost black, serpentine; but not unfrequently light-grey talcose and asbestine rocks are present. Grey felsite rocks and fine-grained porphyritic and syenitic rocks are abundant, as massive developments seldom continuous, in dyke-like lines. Hypersthene and bronzite occur, although not plentiful in the southern end of the belt. Chromic iron occurs on the north end of Lake Harris Range, but indications of copper were not detected. Generally along this western line sulphides are remarkably rare. To the presence of this line of serpentines is partly due the remarkably abrupt and rugged character of the western slopes of the Lake Harris Range. They accurately mark and form the separation-line between the unaltered rocks and the schistose rocks lying to the east, and, where it occurs, the limestone closing the Te Anau series or forming the lowest member of the Maitai series is always in the near vicinity of, or in close contact with, the serpentine belt.

Along the eastern side of that part of the district covered by the Te Anau and Maitai rocks serpentines are also developed, but appear to be more closely connected with the Te Anau than with the Maitai series. The serpentines extend along the junction of the partly metamorphosed Cecil and Walter Peak series from the saddle between the Route and Rock Burns along the higher and western part of the Humboldt Mountains, across the Greenstone Valley, at the back of Tooth Peak, and thence along the Thomson Mountains beyond the boundaries of the district. Whenever from faults or other causes the Maitai rocks along this eastern side of the unaltered rocks make junction with the underlying metamorphic rocks the serpentines appear to be absent, thus appearing to be interbedded with and forming part of the Te Anau series, and perhaps of prior date to the line stretching along the Lake Harris Range

* Geological Reports, 1866-67, p. 28.

and Bryneira Mountains. However, it yet remains to be seen whether or not there are other bands of serpentine intervening between the higher and lower beds of the Te Anau series along their extension north and south in the western part of the district.

The character of the serpentines to the eastward is very similar to what it is on the west side, save that the serpentines, as well as the felsites and other associated rocks, are highly pyritiferous.

FORMATION XI.—PERMIAN.

Kaikihu Series.

These rocks are hardly if at all developed within the district, and were in no way examined. The syncline of the Maitai rocks, which from the spur west of the Greenstone Pass extends south, shows, as seen in the distance, that its southern end is either filled with or crossed by an assemblage of rocks which present different characters from any others seen in or immediately outside the boundaries of the district. These form mountains of tamer outline, and are essentially shingle-producing rocks. Apparently they are a north-west continuation of the great development of which the Hokanui Hills, in Southland, form a part. This would imply that the rocks in question are either wholly isolated, or from Mount Hamilton stretch obliquely across the strike of the Te Anau and Maitai formations unconformably.

Regarding the Te Anau series as the most important member of the group of unaltered formations which form the country between the Eyre Mountains and the crystalline schists along the western boundary of the district, and considering (as there is no room left to doubt) that the Takitimo Mountains and Longwood Ranges are mainly formed of the same rocks, there cannot be any sound objection raised as to the applicability of the term "Te Anau series" to the rocks to which it is applied.

FORMATIONS VI. AND IV.

Younger Secondary and Tertiary Rocks.

These occupy but a small area of the district under review, and are found only at Bob's Cove, on the north shore of the east-and-west reach of Lake Wakatipu, extending north-east from the shore of the lake past Moke Lake, and deeply involved across the eastern spurs of Ben More, crossing Moonlight Creek near the middle of the gorge of that creek, and thence extending along the eastern slopes of Mount Gilbert to Stony Creek. These rocks embrace the coal sequence from the marly greensands to the lower beds of the Pareroa formation, and in places are richly fossiliferous.

On the shore of Lake Wakatipu the beds dip to the west, and the sequence begins with a breccia conglomerate resting upon the older rocks of the Te Anau series. For a short distance the section of the immediately overlying beds is obscure, and the next rocks seen are mottled marly greensands, between which and the underlying conglomerates coal-seams, if at all present, should occur. The prospect of coal occurring in these beds is however very small.

The greensands are overlaid by a blue sandy marl with fossils. These beds pass upwards into marly sandstones containing large spherical and lenticular concretionary masses of a calcareous character, which are often full of fossils. A collection from this horizon was made, but has not yet been carefully compared, so that whether these form the lower part of the Upper Eocene or the higher part of the underlying formation has not yet been determined. The fossils are very similar to those from other parts of Otago, where such are found immediately overlying the coal.

Included in one of the concretionary boulders was a skeleton of considerable size, apparently reptilian, but without tools and proper appliances this could not be extracted. Fragments of a jaw, with long slender Plesiosaurus-like teeth, were all that could be obtained. These fossiliferous beds are overlaid by a band of greensandstone, followed by hard compact coralline limestone, alternating with marly strata, in which fossils are abundant, but very obscure. This limestone may be fully 150 feet thick, but its thickness cannot be exactly determined, as the whole of it is not clearly seen, and, on account of a change in the strike of the rock, looking from the shore it appears to be much thicker than is really is. It is in many places so hard and compact as not to show the least trace of fossils, and these are scarcely seen except where the surface has been weathered under the influence of the waters of the lake.

Under such circumstances it is shown that this limestone is composed wholly of minute and branching corals that much resemble those forming the limestone at Brighton, on the west coast of Nelson. These limestones are overlaid by conglomerates and brown and green sandstone, the latter marly. From beds of the light-brown sandstone the building-stone so much prized and used for various ornamental purposes in the district is obtained. This is a highly indurated sandstone, traversed by a system of joints which cut the bedding-planes at an angle of nearly 45 degrees. The stone is lifted along these joints, and sound blocks of almost any size can be obtained. A curious property of this stone is that it may be glazed by the simple application of heat without in any way injuring the stone, or even the finer ornamentation or lettering worked upon it before being subjected to this process. Fossils collected from this higher part of the sequence show that the beds overlying the limestone belong to the lower fossiliferous horizon of the Pareora series, *Crassatella ampla* being a very abundant shell in the conglomerates, while *Natica solida* is not rare. In Moke Creek and Poverty

Gully, a branch of Moke Creek, there are none but the lower bed rocks present. They consist of conglomerates and red or black shales, with sandstone. Occasionally thin streaks of coaly matter are present in these, and a badly-preserved dicotyledonous leaf may here and there be found; but otherwise than from the peculiarity of their position these rocks are neither extensive nor highly important in an economic sense.

There are, however, associated with these beds quartzose cements which, resulting from the destruction of the neighbouring schistose rocks, may in places prove to be auriferous; and, as these are present in or cross such creeks as Few's Creek, Moke Creek, and Jones's Creek, all of which have proved richly auriferous, some part of the gold obtained from these may possibly be derived from this source. There is with the limestones at the head of Butcher's Gully a considerable development of these quartzose grits, and, although not present where the limestone crosses the Moonlight Gorge, they are again found in the upper part of Jones's Creek.

FORMATIONS I. AND II.

Pliocene, Pleistocene, and Recent Beds.

These cannot at all times be discriminated from each other, except the latter where obviously the youngest beds in the district. Along the shores of Lake Wakatipu the older series, as morainic accumulations (lateral moraines), are found at 1,500 feet above the level of the lake, and, with much schistose material, contain aphanite breccias, slates, and sandstones, and even Tertiary rocks, all of which rocks may be observed at this height on the old track leading across the Ben Lomond saddle to Moke Creek. On the spurs of Ben More, between Moke Creek and Dead-Horse Creek, well-rounded gravels are present as isolated patches at heights 3,000 feet above the sea, or 1,500 feet above the level of the adjoining valley of Moonlight Creek. The same gravels are present in Jones's Creek, and on the saddle between that and Stony Creek rise to a height equal that above stated. Clearly these gravels differ from those at present found at lower levels, due to the action of the streams of which they form the bounding terraces, but to a time and condition of things when the Shotover, or a large stream from the north, passed along the depression in which these gravels are found. Surrounding Lake Wakatipu, and occurring at places favourable for their preservation, the highest lake-level is frequently marked by well-rounded and wave-worn gravels at 1,000 feet above the present level of the lake. An example of this is seen at the height indicated on both sides of the One-Mile Creek, near Queenstown. Further west, along the shores of the lake, these beach gravels do not appear so high, but can be easily traced to heights exceeding 300 feet. Glacier drifts (partly reconstructed) are again seen at lower levels, principally on the west side of the north bend of the lake, and in the immediate neighbourhood of Queenstown. Besides these the lower terraces surrounding the lake prove only the encroachment caused by the streams and the silting-up of the shallower parts of the lake, which deposits have gradually been laid dry within recent times by the lowering of the present outlet.

The ordinary gravels of the present river-beds require no special mention, their origin being perfectly apparent.

COAL DISCOVERIES AT SHAKESPEARE BAY, NEAR PICTON.

REPORT BY ALEXANDER M'KAY.

In compliance with instructions received on the 30th ultimo, I have visited Shakespeare Bay, near Picton, and examined the seam of coal lately discovered at that place. I also made further examinations with the view of determining the extent and prospects of the coal field there, and have the honor to report as follows :—

The coal-seam lately discovered is exposed on the west side of the valley, which extends from the head of the bay in a south direction. It is situated about 15 chains from the shore-line, and crops out in the bed of a small creek coming from the schistose range lying to the westward. The beds in which the coal-seam occurs are inclined at very high angles, 75 to 90 degrees, and near the coal-seam are striking north-north-east. As recent accumulations cover all the lower grounds on the west side of the valley, few opportunities of observing strike and dip are to be had, and where the rocks are exposed they are in this respect but little to be trusted. However, the general direction of the seam of coal may be stated as being north-north-east, but possibly may be either north or east of this as the upper end of the bay is approached. The thickness of the seam is considerable; but I had no means of determining this with exactitude. I was informed by Mr. Renfrew, under whose superintendence the prospecting works are being carried on, that when first laid bare the coal at the surface was 14 feet thick. In order to protect the shaft from the flood-water of the creek, the western portion of the seam is now covered by an embankment; but I saw sufficient to convince me that the seam is considerably thicker than the width of the shaft, which is 6 feet in a south-east and north-west direction, or nearly at right angles to the strike of the seam. The shaft, when I visited it, had been sunk to a depth of 40 feet, coal showing in its north and south sides from top to bottom. In the upper part, clays, which appear to be underlying beds, are seen in the eastern end, and gradually thin out until, at about 12 feet from the surface, the shaft is wholly within the coal-seam.

Ten or 12 feet from the bottom of the shaft a grey calcareous marlstone appears in the western end, and encroaches on the coal-seam in the manner shown by the accompanying section of the shaft, till at 40 feet not more than 2 feet of coal is seen at the eastern end of the shaft.

It has not as yet been proved that the seam maintains its thickness at 40 feet below the surface, the depth to which the shaft has been sunk, and whether it does so or not, from the extraordinary character of the seam, cannot be guessed with any degree of certainty. An attempt was made to follow the coal along its strike in a south-south-west direction. This was done by a tunnel commencing on the opposite side of the creek from the shaft. But a short distance was driven until the seam was lost, or in strike turned sharply to the east. This tunnel had fallen in when I visited the place, and could not be examined. As yet no attempt has been made to trace the coal in a northerly direction since the present discovery has been made, yet it is in this direction that the seam promises to be the least disturbed. In this direction it may be followed by sinking pits at short intervals, which for some distance are not likely to prove of any great depth, some 12 or 14 feet.

In the opposite direction I have already shown that the coal was lost in attempting to follow it along its strike, and, although the coal measures could be touched at almost any point by sinking to a depth not greater than above stated, there is some doubt as to whether the seam would be readily found.

As seen in the shaft, the coal is of a very tender character, and, unless in this respect it improves very much, the greater portion of it must be "won" as slack or small coal. The total thickness being considerable, it is probable that some parts of the seam will be worked in spite of the very high angle at which it stands.

As far as can be made out at present, it is useless to expect that the angle of dip will lessen so as to admit of this, or any other seam which may be found, being worked under the ordinary conditions of a coal-seam.

Prospecting holes and trial-shafts have been put down in several places since I visited the explorations carried on, on the east side of the bay during the latter part of the year 1879.

All of these, where carried on in the rocks belonging to the coal series, have shown that the strata everywhere are dipping at very high angles, generally in a westerly direction.

The last discovery now reported on shows the presence of a seam of considerable thickness; but it remains to be seen if, under the disadvantageous conditions, this can be worked profitably.

On carefully determining the boundaries and extent of the coal-bearing area, I found that its extent was less than I formerly supposed it to be, a trial-shaft and bore, marked No. 3 on the accompanying sketch-plan, being outside the eastern boundary of the younger rocks in which the coal is found.

It will also be seen on the sketch-plan that the southern extension on the west side of the coal-bearing area breaks up into two outlying patches, which, when I last reported on these beds, I supposed to be connected with the main area.

These outliers have been separated from the main area simply by the erosion of the beds of the small streams coming down from the range to the westward, and show that the adjoining south-western portion of the coal-bearing rocks is probably cut off by underlying rocks at or about sea-level.

From the point at which the present workings are being carried on to prove the seam lately discovered, and thence to the shore-line, the younger rocks are deeply involved, and on the west side of the upper end of the bay have been proved to be present to a depth of some 200 feet below the water-level.

Having in former reports treated of these coal-bearing rocks at Shakespeare Bay, describing their various character and general sequence, any remarks of that nature will be unnecessary here.

Ever since I first examined the locality I have been of opinion that there is little prospect of coal-seams being found that would pay to work. This opinion was based upon the fact that the presence of the coal rocks was due to their being caught in between the sides of a great fault which marks the boundary-line between foliated schists to the west and the old sandstones east and south of the Town of Picton. To this fact is due the very high angle at which the coal-bearing beds are found, the indurated condition of the beds, and the crushed character of the coal-seams.

Prior to the present discovery no seams more than six inches in thickness had been found. It has now been shown that a seam of considerable thickness exists, and thus far it may be said that success has crowned the six years' prospecting which has been devoted to the discovery of coal at Shakespeare Bay. Yet, while admitting that a certain amount of coal can be placed in the market, it is extremely problematical whether the seam can be worked with profit; and I would suggest that other parties purposing to sink for coal on adjoining sections should await the success which may attend the opening-up of the present seam. I still hold the opinion previously expressed that the reasons above given, together with the very limited area of the whole field, preclude the possibility of coal being found under workable conditions in such quantities as to materially affect the export trade of Picton.

5th September, 1880.

ON THE MOUNT SOLITARY COPPER LODE, DUSKY SOUND, FIORD COUNTY.

REPORT BY W. E. ROWE.

I HAVE the honor to inform you that, in accordance with your instructions, I have examined the mineral deposit and surveyed the mining operations of the Dusky Sound Copper Mines, west coast of Otago.

I now beg to lay before you in this report the result of my observations, which were principally directed to the elucidation of that portion of the history of this mine subsequent to the visit of Mr. Cox, F.G.S., whose report appears in the Geological Explorations of 1877–78.* Mr. Cox in his report gives a most accurate description of the geological and topographical conditions of this locality; and, as I am unable to add any important information to that already given by Mr. Cox, I shall confine myself to a description of the change which has taken place in the appearance of the deposit since the date of Mr. Cox's report.

W. Docherty, the discoverer of this deposit, formed a company to develop its character. He has acted as mining manager to the company since its formation; he accompanied Mr. Cox in his researches, and also accompanied me to the outcrop situated on the apex of a spur, which has been subject to mining operations, and while there, in answer to questions relative to the appearance of the deposit before any work had been done, he stated that when he accompanied Mr. Cox the apex of the spur presented the appearance of a large, well-defined outcrop of lode-matter, consisting of copper pyrites, associated with iron pyrites, quartz, and calcite, which could be traced a considerable distance along the ridge, manifesting such regularity of strike and uniformity in structure as could leave no doubt as to its continuity in length and depth; but that, on truncating the ridge by blasting in the outcrop, the lode became divided into branches, and eventually only small veins of copper ore, mixed with silica, striking almost perpendicularly through solid felspathic rock, remained, which is precisely the aspect presented by this portion of the deposit at present.

These veins are more free from pyrrhotine and extraneous matter than any other visible development in the property, but are not of sufficient magnitude to warrant the sinking of large sums of money in constructing crosscut levels, as roadways merely to work this particular development of the deposit.

Crosscut levels, however, have another and perhaps a more important mission as prospecting agents, and, taking this view of

* Geological Reports, 1877–78, p. 12.

the matter, I think that money economically spent in crosscutting the highly mineralized spur in question is only a fair mining adventure, and would be resorted to by any mining company in an established mining district; for it must be remembered that all permanent lodes do not crop out on the surface in so short a distance as that exposed by this spur, which is nothing more than an elevated portion of the lode. The lode in its entirety will in all probability traverse miles of the wooded country north and south of this spur, and extend in depth far away under the deep waters of Dusky Sound, just as the famous tin and copper lodes of Botallack, Levant, and Pendeen mines stretch away through the killas and granite cliffs of the Cornish coast, hundreds of fathoms under the bed of the Atlantic Ocean.

However this may be, one thing is certain, that the real value of a mine cannot be known until a section of it has been made either by driving, sinking, or boring across the strata, and openings made upon the course of deposits met with during the operations.

In the present case, however, a particular deposit had been discovered, and money had been subscribed to test its permanence and quality. It was therefore unfair to the deposit- and shareholders to abandon the outcrop when it became disordered, and spend the money in driving crosscut levels to intersect what could have been most conveniently followed until an intimate knowledge had been obtained of the character of the deposit, which would have formed the basis upon which engineering schemes for its future development could have been advised. In fact, the more broken the lode became, the more necessary was it to follow its vestiges until it again formed into a compact lode or expired.

With Mr. Cox's instructions to the management on the one hand, and the mine lucidly showing the way in which those instructions have *not* been carried out on the other, but little sympathy can be felt for those who prefer the rule-of-thumb to scientific advice.

The mining done on the spur consists of an open cutting 15 feet deep on the eastern section, 18 feet long by 10 feet broad, or the entire width of the ridge at this depth—about two weeks' work for two men with blasting materials. This is all the work that has been done on the ridge, and it is in this section that the veins of copper pyrites are found striking into the rock.

I am strongly impressed with the idea that these little veins of copper ore and quartz do not lead to a lode in the centre of the spur, but that they are the offshoots or branches of a lode that formerly rested upon the north-west side of the spur as its foot-wall, and that the lode and strata which overlie the lode became disintegrated and rolled towards the beach, forming the more gentle slopes skirting the "600 feet of sheer fall" described by Mr. Cox in his report. This 600 feet of fall is, in my opinion, the foot-wall from which a deposit has been abraded. And Mr. Cox must have had some idea of this when in describing the spur he said, "It is a razorback ridge not more than 2 feet wide at the summit, having to the north-west or towards the sea a sheer fall of at least 600 feet, the slopes which occur below this point being entirely formed by the *débris* of the cliff, and in all probability containing a larger amount of copper ore than any other point which has been examined up to the present time."

Now, although large masses of metalliferous rocks lay scattered over the surface of these slopes, not an hour's work has been devoted to unearthing the information which must be contained in them.

Leaving the outcrop on the ridge, I visited an opening made 8 feet long upon the course of a formation 5 feet thick striking north 30 degrees east, and underlying north 60 degrees west, or 3 feet in a fathom. It carries a soft matrix on what may be termed its hanging-wall. A quartz vein follows the foot-wall; the intermediate rock is principally gneiss heavily charged with pyrrhotine. This outcrop is situated in a blind gully at the base of the southern side of the spur, about 150 feet below and 400 feet west of the section made on the ridge, and is within 200 feet of the confluence of two creeks which intersect the lowest point of the spur. It is from this point that the spur rises in an easterly direction, eventually becoming lost in the region of Mount Solitary.

I endeavoured to trace the mineral formation across the low part of the spur, but could not again pick it up on the north side. I however, with the aid of a compass, discovered that its direction would be across the lower level somewhere near its mouth; but I had been there the day before with Docherty and had neither heard of nor seen this formation. I returned to the level, and 6 feet from its mouth I found a formation corresponding with that in the gully on the other side of the ridge, possessing the same strike, dip, and character of matrix, but not mineralized to the same extent. This formation breaks into the open about 80 feet up the hillside, and, according to its underlie as compared with the gradient of the hillside, all that once showed above that point has rolled down, forming the slopes which have acted as a buttress to keep the truncated part of the formation *in situ*.

This adit-level has been driven by Docherty's measurement 195 feet in a south-east direction, intersecting mineralized quartz veins, and the formation alluded to before, but discovering nothing valuable. I estimate the cost of driving this adit at £2 10s. per foot. It is situated 390 feet below, and 2½ chains east of, the cutting on the summit of the spur. No water has been struck in this level equal to that struck in the level above, designated No. 2 Crosscut, which is situated 110 feet nearer the summit, 2½ chains west of the adit-level, and immediately under the open cutting.

This level has been driven south-east 95 feet through a much less mineralized stratum than that crossed by the adit-level, intersecting at 95 feet a wall or well-defined "head," carrying a soft band (size of seam 2 inches) of highly-mineralized slate, but showing no copper ore. A quantity of water issues from the roof at this point. Levels have been opened upon this soft seam 18 feet each side of the crosscut. As this wall or head had not been broken into I had no opportunity of judging of its character, but before any undue importance should be attached to it it should be broken through, as it is probably an intersecting band of granite, perhaps identical with that struck in the adit-level some distance from the face—about 10 feet. The formation crossing near the mouth of the adit is not seen at this distance up the hill.

The information obtained of the actual commercial value of this property, or the industrial benefit which it may be capable of conferring upon the people of this colony, is not equal to the capital expended. If Mr. Cox's advice, to test the outcrops before doing any deadwork, had been adhered to, and his suggestion that the slopes contained mineral wealth acted upon, the £3,000 which has been sunk on this property would have given shareholders exhaustive details of its intrinsic value. The actual work done is a small open cutting on the ridge, and 320 feet of crosscut-driving, estimated (£40) : cost, £840. This sum should have covered the total expenditure on the mine. The higher level should be driven 12 feet across the strata, and the adit driven 9 feet to intersect what they were started for—that is, if surface conditions are maintained.

Illustrative samples of the deposit are submitted herewith.

16th January, 1880.

ON THE ANTIMONY MINE AT HINDON, TAIERI COUNTY.

REPORT BY W. E. ROWE.

I have the honor to inform you that, acting under your instructions, I have inspected the Hindon Antimony Mine.

It is situated fourteen miles from the Outram Railway-station as you proceed along the road through Mullocky Gully, over the range, and across the Taieri River into the Hindon District. Its precise locality is on the summit of a spur, which takes its rise 4 chains from the margin of the Taieri River, at a place known as Haggerty's Crossing. The deposit is a quartz lode containing the sulphide of antimony (stibnite) and peroxide of iron. The presence of the latter is due to the decomposition of iron pyrites, which will be found again in its original form as depth is acquired.

The lode, which is 18 feet thick, strikes north-west and south-east, and dips north-east into the hill at an angle of 45 degrees, or 1 in 1. Its outcrop occupies an altitude of 200 feet from the flat ground skirting the base of the spur, from which a level could be conveniently driven on the strike of the lode, and its value ascertained at this depth without incurring heavy disbursement. The mouth of such a level would only be just across the Taieri from the railway-line which is now being constructed to the Clyde and Cromwell. A wire tramway, punt, or bridge could be easily constructed to connect the mine with the railway-line.

The stibnite existing in this lode is associated more especially with the quartz resting on and near the foot-wall, although there is no marked division in the physical character of the lode, either in colouring-matter or structure, indicating that it is confined to this wall by any fixed law regulating the lode; but rather that it does not at present extend far away from the wall in any appreciable quantity.

For so large a lode, and one possessing an eccentric strike, its walls are exceptionally regular, being comparatively parallel in strike and dip for the whole distance revealed by a cutting 81 feet long by 8 feet deep, made along its course or strike.

I do not look upon this deposit as a remunerative antimony property; nor do I consider that it should, upon the evidence yet adduced, be designated an antimony mine.

I have no doubt as to the existence of antimony throughout this mine, and in all probability large masses of it will be found as the lode becomes more concentrated and auriferous in character; and, if such should be the case, the close proximity of the railway to the mine will render this ore a valuable addition to the property. But the deposit is essentially an auriferous quartz-lode, passing through mica-schist, which extends miles away from the lode; and, although this deposit is not payable throughout its large outcrop, this should not deter the company from spending, say, £400 in driving a level of ordinary size on the strike of the lode, making the foot-wall one side of the level, and taking out as much quartz and antimony ore as the size of the level requires.

The underlie of the foot-wall will probably preserve it from breaking, and the increased hardness of the lode-matter at this depth will probably make it self-sustaining, so that timber, which is difficult to obtain in this district, may be dispensed with.

Care should be taken to separate the antimony ore as perfectly as possible from the quartz during the process of breaking down the lode.

At intervals of 20 feet, in proceeding with the level, crosscut drives should be put across the lode, intersecting the hanging-wall. And, if deemed necessary, rises should be put up or winzes sunk connecting the level and crosscuts with the surface, thereby making a complete section of the deposit, and thoroughly ventilating the mine.

An average cost of 10s. a foot should cover the expense of all driving, rising, or sinking in this ground to the depth of the river-bed.

22nd January, 1880.

ON THE STONY CREEK ANTIMONY MINE, WAIPORI, TUAPEKA COUNTY.

REPORT BY W. E. ROWE.

I HAVE the honor to inform you that, in accordance with your instructions, I have inspected the Stony Creek Antimony Mine, Upper Waipori, Otago. The mine is situated eight miles north-west of the Township of Waipori, near the head of Burnt Creek (celebrated for its gold-producing qualities), and on the rising ground leading to the Lammerlaw Ranges. Its distance from the Tuapeka Railway-station is twelve miles, and, as this is the nearest and most convenient railway dépôt that can be obtained, a traffic route will be most likely opened up in this direction by the owners of the mine.

The lode crops out in Stony Creek, and strikes across a spur, showing up again in a blind gully which intersects Stony Creek at the point of the spur. It is 2½ feet thick, striking north 70 degrees east, underlying north 20 degrees west, 2 feet in 1 fathom. Structure, massive; formation, regular; walls, friable, consisting of decomposed schist, interspersed with small veins of quartz intersecting each other in all directions.

Mineralogically, the lode is composed of fibrous and compact stibnite, the former being almost pure sulphide of antimony, the latter containing on an average 30 per cent. of gangue in the form of quartz and peroxide of iron.

The distance between Stony Creek and the Blind Gully across the spur on the line of lode is 200 feet: beyond this I did not trace the deposit.

An adit-level, opened 7 feet above the bed of Stony Creek, has been driven east on the course of the lode 30 feet, showing a very promising lode in the face.

As the bottom of the level was covered with the *débris* fallen from the sides (or walls) of the level, no timber having been used, I could not determine its character going down, but Mr. Candwell, who prospected this deposit, assured me while on the ground that the lode was as solid and regular on the bottom as that exposed in the face of the drive.

The returns from four tons of ore broken in this drive and sold show 47 per cent. of metallic antimony.

A shallow shaft has been sunk on the lode on the top of the spur equidistant from the creek and gully, from which 30 cwt. of ore was taken and sold with slightly better results.

Stony Creek is a prominent watercourse, and of sufficient volume to supply all the requirements of an extensively-worked antimony mine.

The only drawback in local requirements likely to be suffered by this company will be the want of timber for the mine, as the district is treeless. For smelting purposes, however, but little inconvenience will be occasioned, as a very large area of moss, which will make excellent peat, exists close to the mine, which will be quite effective, with very little coal and lime (and perhaps quite alone), in bringing this easily-reduced ore into a concentrated state of rough metal.

In conclusion, I consider the working of this mine a most legitimate undertaking, and one likely to be beneficial to shareholders and the colony. Yet, as large sums of money must necessarily be expended in constructing roads, and eventually smelting-works and dressing-floors, before the full advantages of the deposit can accrue to the company, I strongly advise that, before a single penny be launched out on any of these works, the mine be developed in the following manner—namely, that the level already commenced be extended at least 200 feet, and the shaft struck through and connected with the level.

The longitudinal (or miners') dip of the shoots of ore met with in driving or rising must be carefully watched, so as to obtain data for sinking on the lode in a convenient place for intersecting these shoots of ore at a point from which they can be most easily operated upon.

A shaft should be sunk upon the lode at least 60 feet deep from the bottom of the adit-level. Scientific advice should then be obtained, and plans and specifications with a cost estimate furnished to guide the company in their future proccedings.

26th January, 1880.

ON THE WAITAHUNA COPPER LODE, NEAR WAIPORI, TUAPEKA COUNTY.

REPORT BY W. E. ROWE.

I HAVE the honor to inform you that, in compliance with your commands, I have examined a mineral deposit, consisting of copper and iron pyrites, occurring in Reedy Creek, Waitahuna River, in the Province of Otago. It is situated about six miles south-west of Upper Waipori, and ten miles to the north-east of the Waitahuna Railway-station, at the point of a leading spur, about two miles from an imperfectly-made road leading through this district from Waitahuna to Waipori. It crops out in the bed and enters the eastern bank of Reedy Creek, or, rather, that part of the Waitahuna River near its source called by some local geographists Reedy Creek.

The road mentioned above has been made (or laid out) by local enterprise, subsidized by Government, with the view of promoting the settlement of the land through which it runs. The Government have also appropriated a sum of money to place a bridge across the Waitahuna River, the want of which is the only serious obstacle to a mining proprietary obtaining by a small outlay a good road close to the mine, and having the advantage of an agricultural population settled in its immediate vicinity.

The history of this deposit is that a "cupriferous gossan" attracted the attention of gold-seekers, who "wing-dammed" the river-bed from the point of lode-outcrop to a distance of 70 feet down the stream, cleaning up in that distance 24 oz. of gold.

The lode-outcrop in the river-bed was worked to a depth of 4 feet, the lode increasing in size and quality. The bed was then abandoned, and a shaft sunk close to the river-bank, which intersected "at a depth of 9 feet a lode 4 feet thick of yellow ore, of a superior quality."

A shaft was then sunk 20 feet deep a little to the north of the trend of the lode for the purpose of catching the underlay, but as the underlay is in the opposite direction this shaft did not strike ore. A flood then came and swept away the dam, and filled the river-cutting and the two shafts with its *débris*. The actual position of the mine at present is that, at a point in the Waitahuna River named Reedy Creek, whose water flows at this point nearly due south towards Waitahuna, a mineral deposit occurs, assuming the form of a lode striking south 70 degrees east and dipping south 20 degrees west across the stream, and entering the east bank of the river.

The surface manifestation of the deposit is of a meagre character, being confined to a small vein of copper and iron pyrites—the latter predominating—passing through a slightly-mineralized formation 2 feet thick as it enters the river-bank to the extent of 4 feet above the river-bed, but it cannot be traced for any distance on the surface of the hill except by a deposit of ferruginous sand, which assumes the form and direction of the mineralized band containing the small vein. But this in itself is not significant of a weak or poor lode so much as of the lode being contained in firm compact strata, and enclosed in a fissure possessing firm walls. Persistent lodes holding down and confined within solid walls do not usually crop out so abundantly on the surface as irregular or local deposits existing in a more disturbed and friable formation.

The lode as exemplified by the large fragments of ore which are strewn along the banks of the river is of a very uniform structure, showing regular bands of ore alternating with bands of mundic, presenting the striated form peculiar to permanent deposits, and showing on the faces or joints, when broken parallel with the plane of contact, the variegated variety known as "peacock ore."

Judging from the size of the masses of ore just mentioned the lode cannot be less than 2 feet thick at that point in the shaft from which they were taken. About 6 cwt. of the lode, taken from the outcrop in the bed of the river and removed a little distance up the hill, is now reduced by atmospheric influence to a pyritous powder mixed with the peroxide of iron and protoxide of copper. The bulk of this surface variety is iron pyrites.

The river-bed lying between the two shafts, including the area occupied by the shafts, measuring altogether 12 feet, is the only place in which the deposit has yet been discovered, or has indeed been searched for.

These shafts are now filled to the brim with river *débris*, and grass is growing over their mouths.

The ore once exposed in the river-bed has been worked to a depth of 4 feet, and the cutting made in extracting the ore is silted up by the river, leaving no trace of the direction of the deposit. The only guide to this information is the exposure of the mineralized band on the bank of the river, which *seems* to dip south, but contains a vein of ore which *does* dip south, and which I judge will be the permanent dip of the deposit, and which is, for all practical purposes, an east-and-west lode dipping south, and composed of copper and iron pyrites, the latter predominating in the surface variety, but rapidly giving place to the former in samples obtained from the shaft, which are not only richer in copper, but bear the characteristic marks of a strong lode.

The geological formation containing the fissure is a grey arenaceous or quartzose *schist*, striking, so far as I could ascertain, south 20 degrees east, with intersecting "heads," forming in some instances miniature fissures in the river-bed, striking north 60 degrees east.

In conclusion I may state that, although I visited this mine twice—once from Waitahuna and once from Waipori—and did my best to obtain data, I failed to discover sufficient evidence, owing to the unsatisfactory state of the mine, to warrant a pronounced opinion as to the exact relations of the deposit or its paying qualities. And I consider the request for an official inspection of this mine without first cleaning out the shafts and exposing the deposit to have been inopportune. Yet I am quite certain that the masses of solid ore taken from the shaft sufficiently guarantee the existence of a strong lode existing in this locality.

I advise levels to be opened on the strike of the lode and driven 50 feet into the river-banks away from the river, and shafts sunk from the bottom of the levels on the lode, before any other expense is incurred.

1st February, 1880.

ON MOUNT SOLITARY COPPER LODE, DUSKY SOUND, FIORD COUNTY.

FURTHER REPORT BY W. E. ROWE.

The following report, addressed to the manager of the Dusky Sound Copper-Mining Company, has been forwarded to me for publication. James Hector.

Report.

My operations were first directed to an examination of the strata revealed by a natural section of the country made by a river which derives its source from the tributaries emanating from the western flank of Mount Solitary, and disembogues into Dusky Sound at a point known as Docherty Bay; but with the exception of the copper lode, which is intersected by this river, I saw nothing of sufficient importance to mention here.

I next examined the fragmental lode-matter contained in the river-bed and scattered over the beach from the low-water mark to the junction of the copper lode with the fundamental granite and overlying stratified rocks, and obtained results which I shall notice further on.

The granite at this point in the river rises across the stream to a perpendicular height of 100 feet, over which a large volume of water rolls with tremendous force into the seething basin excavated in the river-bed by its eroding influence. The superior solidity of the granite underlying the lode to the overlying metamorphic rocks forming its hanging-wall strata is here made very manifest: whilst the former has retained its prominent position, the latter have succumbed to the degrading influence of the stream to the extent of about 300 feet in a distance of 4 chains down the river. I mention this because Professor Hutton says, "With the exception of a few veins, I saw no granite in Dusky Sound." (See Hutton's Geology of Otago, p. 41.)

The copper lode crosses the river just immediately at the base of the waterfall in a well-defined form, striking nearly east and west. From a mining point of view it was a most encouraging sight to stand amidst the spray of this cataract and estimate its value as a motive-power applicable to the working of turbines, over-shot wheels, hydraulic engines, and other minor machines used in winding, and in crushing and dressing metallic ores, *with a copper lode cropping out by its side.*

This is the lowest point at which the lode has been seen in position, and, as it is only visible for a foot or so above the bed of the river as it enters the side of the mountain in its south 75 degrees west course, it is evident that the productive and unproductive ore-bands or shoots contained in this deposit will, in their alternations with each other, possess a longitudinal dip of at least 45 degrees from the horizon to the south-west.

Although I saw a large band of mineralized rock, I did not see this outcrop when I visited and examined this spot during my former trip. It is therefore probable that its appearance on the surface is only of a recent date, and has perhaps been occasioned by the wearing action of the waterfall during the recent winter floods.

Leaving the river, I proceeded to examine the loose deposits accumulated on the adjoining flat, which is about 4 chains broad, and stretches right away from the beach to the foot of the spur containing the outcrop of copper ore, and into which the crosscut levels have been driven to intersect it.

These deposits have resulted from the disintegration of the lode and hanging-wall strata forming the north-west side of the spur first mentioned.

The masses of lode-matter lying along the river-bed, and those associated with the *débris* on the flat—some being several tons in weight—were operated upon with drills and dynamite, and, when broken, no matter whether they were from the river-bed or flat, big or small, they invariably presented a homogeneous constitution, copper pyrites and iron pyrites entering into such intimate combination with each other as to render it extremely difficult to determine without analysis which ore predominated, the whole mass being composed of these substances. Four samples which I have analyzed from these deposits, including river-bed deposits, varied from 3·4 to 17·9 per cent. of metallic copper, striking an average of 9·2 per cent.

No. 1	sample gave	3·4	per cent.
2	"	17·9	"
3	"	5·5	"
4	"	10·	"

A great difficulty will be experienced in hand-dressing the poorer varieties of this class of ore. I should say it would be almost impossible to do so without first effecting its complete pulverization. But should such a necessity occur it will not materially augment the working expenses of the mine, as an unlimited supply of water at a great height is available on the spot, and can be easily and inexpensively converted into motive-power of sufficient magnitude to meet all requirements. I have reason, however (which will be adduced), for concluding that these mineralogical conditions will not be found to exist to any great extent as the lode becomes opened in depth to the north-east.

The lode, in its north-east course from the outcrop in the river-bed, rises at an angle of 45 degrees, which coincides with the angle of dip possessed by the shoots of ore succeeding each other throughout the deposits. It exposes a copious outcrop composed of quartz, calcite, gossan, iron pyrites, and copper pyrites.

At the foot of the spur and for some distance up the ridge a quartz vein 2 feet thick, of a drossy character, containing detached crystals of chalcopyrite, occupies the foot-wall of the lode. The lode here becomes separated from the basement, granite, for some distance, cutting through gneiss, mica-schist, hornblendic and felspathic rocks, as it rises in elevation until the point is reached where an extended protrusion of the granite brings it again in contact with the lode, and forms the head of the blind gully which has been excavated out of the softer material lying between the granite and the lode up to this point.

At the point of contact the lode becomes deflected from a direction north 45 degrees east to a direction north 55 degrees east. It is from this point that a favourable change takes place in the mineralogical phase of the deposit, which consists in the absence of pyrrhotine and the substitution of ordinary iron pyrites, which is not so intimately mixed with the cupreous ore as was the former, but existing in distinct layers, nests, and crystals, the copper ore exhibiting the same phenomenon. The ore occurring in what I shall, for convenience sake, call the eastern shoot, is the variegated sulphide of copper, containing a large proportion of bornite, which, when pure, yields 55·6 per cent. of metallic copper, whereas ordinary copper pyrites, when pure, only gives 34·6 per cent.

Bornite is found in Cornwall associated with copper pyrites in the most productive mines, and is called by miners "peacock ore:" it is also found pure in Germany, where it is called "buntkupferz," or horse-flesh ore.

The lode then stretches away north-east through the mountain. How far it extends I do not know, but my opinion (formed from a survey of the country passed over during my trip) is that this and kindred lodes under various conditions will ultimately be found to traverse the entire country from Dusky Bay to Chalky Inlet, embracing West Cape, Resolution Island, &c., on the south-west, and on the north-east to Jackson's Bay and the Haast River, passing in the latter direction right through the crystalline formation, and across a narrow belt of palæozoic containing the mineral series of strata known in the South Island as the mineral belt, and from thence into the foliated schists, skirting the north-west flanks of Mount Earnslaw and Mount Aspiring, and again forming a line of junction with the crystalline rocks at Jackson's Bay and the Haast River (see Dr. Hector's exhaustive Geological Map of New Zealand). It is most likely that the miners prospecting for gold in the neighbourhood of Jackson's Bay and the Haast River will at some time or other come across rich deposits of copper ore.

On breaking the surface of the open cutting, at the apex of the ridge containing the outcrop and tunnels, small veins of copper pyrites were found to exist: some ran along the joints, while others struck through the ferruginous rock.

An examination of the north-west declination of the ridge elicited corresponding results. A short hole blasted in the face of the upper cross-cut level revealed a vein of quartz: this had been supposed to be the junction of the lode with the granite and metamorphic rocks, and levels were driven in a seam of decomposed mica, slightly impregnated with iron, and considerably indurated, which lay under the metamorphic rocks and upon the quartz vein.

Continuing the investigation of this level towards its mouth, promising veins were discovered, none of which, however, taken separately, were of sufficient size to pay for working; but they appeared to be converging to the formation of a main deposit at a greater depth—i.e., those near the mouth of the level dipped towards the face at a much lower angle than those nearer the face, while at the face the dip was just vertical.

The lower level manifested the same characteristics, but on a more extensive scale.

The end of the adit-level is at present in mica-schist interstratified with veins and layers of quartz, containing segregated crystals and nests of the rare mineral, sulphide of molybdenum.

A well-defined lode 4 feet in size, trending south 40 degrees west, underlying north 50 degrees west, crosses this adit near to its mouth. I caused it to be driven south-west to the extent of 10 feet; it maintained its size and mineral character throughout this short distance: its matrix is composed principally of quartz, peroxide of iron, and decomposed mica of a very soft character.

MALCOLM'S LODE.

The outcrop of Malcolm's Lode is situated near the water's edge of the southern arm of Dusky Sound, about 400 yards from the House Beach, in the hollow of the first bend towards the head of the Sound. Its surface-development exhibits a rare illustration of the "iron-hat" deposits of Cornwall and Germany. Its vicinity, like the neighbourhood of the main lode, has been the scene of great surface disturbance: hundreds of tons of ferruginous rock, cemented ironsand (red ochre), in the form of mud, are now lying on the line of lode, being deposited there by a gigantic slip of the lode and country from a much higher elevation than that occupied by the outcrop now visible.

Owing to these circumstances, it was difficult to obtain a satisfactory "view" of the deposit in position, such a large amount of loose material having to be removed before favourable conditions could be secured for doing so.

Taking the information that was obtained from the opening that was made, in conjunction with other reliable indications, as the basis of my survey, I found that the lode strikes north 85 degrees east, and underlies north 5 degrees west, at an angle of 70 degrees from the horizon, and therefore taking up a line of intersection with the main lode near its point of deflection (see plan of lodes). What its exact size is I do not know. The strata here strike north 30 degrees east, and dip to the north-west: they consist of soft hornblende, chloritic slates, porphyritic rocks, and gneiss-granite, intersected by ferruginous quartz veins. This deposit consists of cemented ironsand and a firm siliceous gossan, containing the sulphides of iron and copper. The ores occur in detached deposits, scattered veins, and branches, assuming a most irregular form: its very irregularity, however, gives it an aspect of profusion and permanency which a more regular or less complete association of minerals would not assume.

The surface aspect of this deposit, including its strike, dip, associated minerals, and the character of the strata it cuts through, indicates large copper-producing capabilities. This deposit is intersected by another, which is delineated on the plan as the north-and-south lode: it strikes north 10 degrees east, and underlies west: it does not bear a favourable comparison with the other lodes, being composed principally of friable ferruginous slate.

Although I failed to discover any appreciable quantities of silver* in the lease, yet, on testing what I considered congenial matrices, I found this metal present, the most satisfactory result being obtained from a thin vein of iron pyrites containing a quantity of nickel. I also found nickel associated with pyrrhotine in large masses of loose rock.

As a matter of opinion, based upon local indications and experience in deposits existing under similar geological conditions elsewhere, I should say that the north-and-south lodes found here intersecting the east-and-west lodes will, in those portions of such fissures which are found traversing the basic rocks, contain payable deposits of argentiferous ores.

It will be seen, by looking at the plan showing the bearing of lodes, that Malcolm's lode strikes for the opposite flank of Mount Solitary to that traversed by the main lode. This is important, inasmuch as it decides that the country has been systematically fractured by the upheaval of the granite bosses, thereby indicating the existence of two fissures, accompanied by the usual minor fissures and intersections peculiar to large mining centres.

Again, experience teaches that productive copper lodes worked in the vicinity of great granite protrusions occupy the north-and-south flank of such protrusions.

Malcolm's lode strikes for the south-west flank of Mount Solitary, whilst the main lode occupies the north-west flank, intersecting each other on the north-west flanks of the Mount Solitary system of granite hills, and on the south-east flank of Mount Pender, thus as it were forming conduits for bleeding the entire country of its mineral wealth; at the same time forming deep reservoirs for receiving and containing the concentrated minerals introduced by

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* That is, defined deposits.

infiltration and other lode-making processes, the richest being probably the first deposited and consequently the deepest, the heated, moving, igneous rock producing favourable conditions for the formation and percolation of metallic salts, to be ultimately received by these fissures and converted into metallic ores. The great elevation of the granite bosses, overlaid by strata graduating into micaceous and talcose schists (becoming in places gneissic by the introduction of felspar), succeeded by dioritic, hornblendic, and felspathic, passing into argillaceous slates capped by limestone, the whole intersected by intrusive granite veins, denote this to be a district in which metalliferous deposits of great magnitude may be expected to exist, and in which the fissures may be expected to penetrate to a great depth: consequently a much larger amount of unproductive surface development may be anticipated than if the fissure system were on a smaller scale or less capacious.

For future guidance in driving crosscut tunnels or levels along the course of deposits contained in your lease, it may be well to state here that the country possesses a very distinct jointal structure of a complete character, consisting of two main sets of joints, one running south 30 degrees east, the other north 55 degrees west, the former dipping north 10 degrees east, the latter dipping south 50 degrees west, intersecting each other at an angle of 65 degrees. Other minor sets intersecting these and each other exist, but are of less importance. The joints form clearly-defined "heads" or faces, and are uniform in their strike and dip; they also contain in places segregations of copper ore and decomposed mica, impregnated with iron, in their interstices.

These joints therefore, in their filling-up and "faces," present a striking resemblance to the walls of a lode, and may be (in fact have been) taken for such (see plan of upper tunnel). Consequently the attention of the men engaged in the construction of such tunnels and levels should be drawn to the existence and demeanour of the jointal system, so that no puzzling questions may arise as to which should be followed and which should not: such indecision often causes great delay and unnecessary flexuosites in the roadways and levels, and perhaps misleading to such an extent as to prevent the "lode" from ever being cut. The accompanying diagram* delineates the hypothenusal, horizontal, and perpendicular distances and angles which will be made by the intersections of the tunnels with the lode: that is, supposing the lode to be vertical, AB represents the distance and angles lying between the adit and apex of the ridge; AC, the horizontal distance of levels required; BC, the height of backs obtained; dotted lines represent the same conditions in the upper level. It is supposed in this diagram that the levels ought to be driven at right angles to the ridge where the outcrop of the lode was first found running right along its apex:

* Diagram marked H.

the nearest point to this would be south 20 degrees east; while the present levels range from north 20 degrees east to south 10 degrees west (see plan of levels); consequently not near so great a distance has been acquired across the strata as the distance driven would seem to indicate. The strata have been crossed in the tunnels obliquely and sometimes followed, which I believe to be due to a confused appreciation of the jointal system of the belt.

The surface conditions of this mine are exceptionally favourable: navigable waters skirt the base of the chain of mountains, and the lodes traverse these mountains at a great altitude.

A level can be opened on the course of the deposit somewhere near the foot of the spur, gradually acquiring backs for stoping, ranging from 0 to 1,500 feet; or a crosscut level can be driven from a point on the flat, intersecting the lode in a distance not exceeding 100 fathoms, giving close on 2,000 feet of backs; or, should future operations prove the continuity of Malcolm's lode, a level could be simultaneously opened upon its course east, thereby securing a soft and inexpensive channel of ground to work, and which, leading up to its intersection with the main lode, would form another field for operations.

This mode of opening up the deposit will have the advantage of connecting the north-and-south lode with the east-and-west lode, *i.e.*, the main lode with Malcolm's lode, at their point of intersection, where the largest and richest portion of the deposit at this depth may be expected to exist. The further exploitation of the mine from this point will be very convenient and simple.

A chamber 40 by 40 feet and 12 feet high (having for its centre the point of intersection), and furnished with flat sheets or turning-tables for shunting the trucks, will form the centre from which four avenues on the course of the lodes may be constructed right into the heart of the mountain.

Payable shoots of ore passed through in these levels should be marked, and their dip understood, so that when stoping commences "rises" may be put up at convenient places for commanding the most favourable conditions for taking out the ore and promoting ventilation.

Timber for mining, dressing, and smelting purposes clothes the mountain-sides and undulating slopes in the immediate vicinity of the proposed site for machinery and smelting-works, and from which an unlimited supply can be obtained for the various requirements of the mine at cutting cost. Water in an unlimited quantity and at a great height, as before mentioned, is obtainable as a motive-power and diluting agent on the spot at no expense. Labour was never so plentiful in New Zealand as at the present time.

The copper market has been depressed for a considerable time, which has had a tendency to weed out the poorer mines and those worked to a great depth at great expense; consequently the supply has been gradually decreasing, and the metal market is therefore acquiring a healthier tone.

Operations will be for years confined to driving and stoping; there will be no shafts to sink, no expensive winding and pumping machinery to erect, work, and keep in order; and no carting or railway expenses will be incurred. The work will thus be free from those expensive items the aggregate of which forms the bulk of the expenditure generally incurred in working copper mines at a great depth and surrounded by less favourable circumstances.

The mineral development of this district is on a grand scale, and will have to be treated in an extensive manner before an adequate idea can be formed of its value.

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Colonial Museum and Geological Survey Department.

JAMES HECTOR, C.M.G., M.D., F.R.S.,

DIRECTOR.

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